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ABSTRACT

Addressed to vocational, or academic middle or high school students, this book reviews mathematics fundamentals using metric units of measurement. It utilizes a common-sense approach to the degree of accuracy needed in solving actual trade and every-day problems. Stress is placed on reading off metric measurements from a ruler or tape, and on changing units by moving the decimal point. It is designed to reinforce the student's ability to solve problems and includes eight units: Introduction to Metrics, Working with Metric Math, Linear Measurement, Area Measurement, Volume Measurement, Mass or Weight, Temperature Measurement, and Metric Threads. Each unit contains from one to six lessons with each lesson including objectives, text material, and learning activities (discussion questions or written exercises). The seven appendixes include numerous conversion charts as well as charts of screw-thread sizes. (HD)

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Department of Education
Division of Vocational Education

INTRODUCTION TO METRICS

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To the Teacher

This manual is addressed principally to vocational school students, although the selection of material is actually broad enough to make it eminently suitable for students in academic middle schools or high schools.

Learning to "think metric" is the key to learning the new system of measurement, the metric system. Learning to use metric units is like learning a new language. In a sense, students will become bilingual in measurement. For the next few years, their primary measurement "language" will still be the English system. Their secondary measurement language will be the metric system. Gradually, as the metric system becomes more commonly used, it will become their primary measurement language, and the English system of measurement will fade into the background.

Students must learn to visualize distances, volumes, weights, etc. in metric units. They must think kilometers, cubic meters, grams, kilograms, etc. Converting from English units to metric units should be discouraged, because it deters students from thinking metric. The use of realistic vocational problems with actual metric measurement tools should be encouraged, so that students can attain a working, thinking knowledge of the metric measurement system.

This book is a review of mathematics fundamentals, using metric units of measurement. It utilizes a common-sense approach to the degree of accuracy needed in solving actual trade and every-day problems. Stress is placed on reading off metric measurements from a ruler or tape, and on changing units by moving the decimal point. The book is designed, finally, to reinforce the student's ability to solve problems involving linear distances, areas, and volumes.

Attention is called to the numerous conversion charts in the appendix, as well as charts of screw-thread sizes.

Acknowledgements

Appreciation is extended to the following for their contributions.

Metric and Multistandard Corporation, Elmsford, New York for *"How to Use Our Thread Identification Chart"* and *"Thread Identification Chart."*

Society of Automotive Engineers, New York, N.Y. for *"Standard J390 – Dual Dimensioning."*

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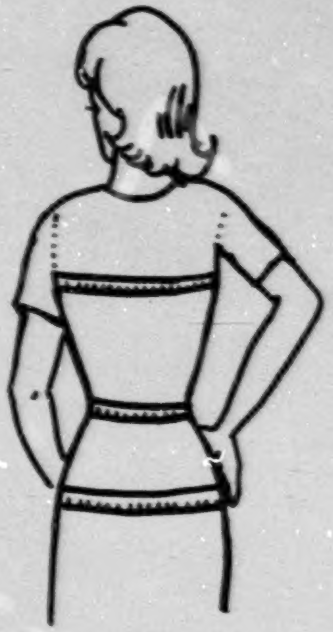
I – INTRODUCTION TO METRICS

Lesson 1 Why Change to Metric Measurements?

Objectives:

1. You should be able to explain why many American manufacturers are using metric measurements for their products.
2. You should be able to explain how a change to the metric system will affect your trade area.

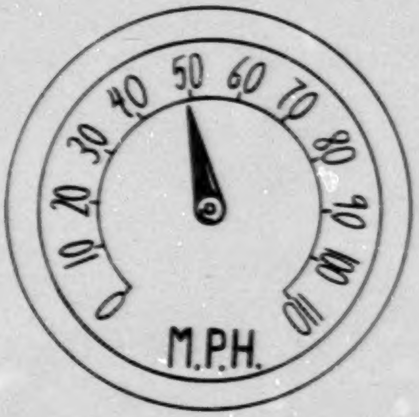


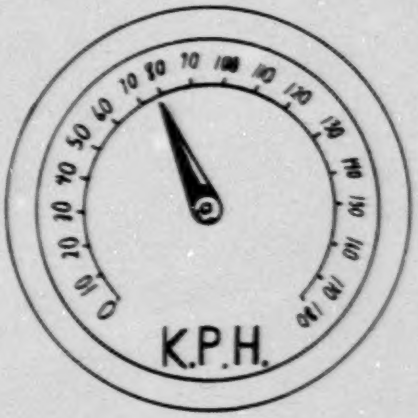
World trade is important to the United States. We buy oil, sugar, television sets, cameras, cars, and other products from foreign countries. Using the products (clothes, autos, etc.) is easier if we use the same units of measure.

For example, would you know how to buy clothes in England? Metric centimeters are used for clothing sizes in England. A woman who measures 34-24-36 in inches is 85-60-90 in centimeters.

Clothing sizes are different in countries that use the metric system. When we sell clothing to other countries, we must use sizes that they understand. A 24-inch waist may be the same as a 60-centimeter waist, but they sound different.

We use auto speedometers to measure speed. Your car measures speed in miles per hour. VW's made in Germany for Germans measure speed in kilometers per hour. Look at these two speedometers. Which speedometer measures speed like a VW sold in the U.S.? Why?





Metric measurements change more than just the speedometer of a car. All of the nuts and bolts of most foreign cars are in metric measurements. Foreign cars need metric tools. They also need metric nuts, metric bolts, and metric replacement parts.

Using two measurement systems costs more money. All other industrial nations use the metric system. Many of these other nations say, "Sell metric to us or we won't buy." American businesses make products in one set of measurements (inches, pounds, etc.) for the U.S. market; then they have to make the products in another set of measurements (metric) for foreign trade.

Some U.S. companies are changing to the metric system to save money. The Chevette was the first American car to go metric. This was in 1975. For the first time, one U.S.-made automobile made by one set of measurements (metric) could be sold all over the world. Thus Chevettes exported to Europe could be repaired with replacement parts made in Europe.

I'm METRIC!
I'm different!
M

Hey man! I'm Going to Europe!!

The Caterpillar Tractor Company has also changed to the metric system. Their tractor parts are interchangeable all over the world. So a tractor part made in France fits a tractor made in the United States. IBM and International Harvester companies are examples of other companies that have gone metric.

The metric system isn't new. Metric measurements have been used for many years for prescription drugs and photographic equipment. For example, the 35 mm camera uses 35 millimeter film. Nutrient contents of foods are listed on labels in grams and milligrams. Each year many products switch to metric measurements.

Get ready. Metric is coming. Will you be ready?

For Class Discussion

1. How will metric measurements change clothing sizes?
2. Do mechanics need new wrenches for metric automobiles?
3. You need a metric hat. Would you use a measuring tape or a math problem to find the answer? Why?
4. When carpentry goes metric, list the metric tools that the carpenter will need.
5. When air conditioning, heating, and refrigeration go metric, list the gages that will have to be changed.
6. What tools will change in some of the other trade areas?
7. How will a change to the metric system affect your own trade area?

UNIT II – WORKING WITH METRIC MATH

Lesson 1 **Reading and Writing Decimals**

Objective: You should be able to read and write decimals.

Decimals are part of our daily lives. Money is usually written as a decimal. All metric measurements will use decimals. So using decimals is important in a metric world.

Decimals are really fractions that have denominators of 10, 100, 1000, etc. Like other fractions, all decimals are *less than one*. In decimal fractions, we replace the denominator of the fraction with a decimal point, so. . . .

- The fraction $\frac{9}{10}$ becomes the decimal .9,
- The fraction $\frac{9}{100}$ becomes the decimal .09,
- The fraction $\frac{9}{1000}$ becomes the decimal .009.

Study the table below. It will help you understand decimals and learn how to read them.

Decimal	Fraction	Read
.1	$\frac{1}{10}$	one-tenth
.01	$\frac{1}{100}$	one-hundredth
.001	$\frac{1}{1000}$	one-thousandth
.0001	$\frac{1}{10000}$	one ten-thousandth
.00001	$\frac{1}{100000}$	one hundred-thousandth

In the same way,

.3 is read "three-tenths"

.03 is read "three-hundredths"

.003 is read "three-thousandths"

and

.23 is read "twenth-three hundredths"

.724 is read "seven hundred twenty-four thousandths"

Whole numbers with decimals, or mixed numbers, can be read as follows:

3.4 is “three *and* four-tenths”
or “three *point* four”

17.83 is “seventeen *and* eighty-three hundredths”
or “seventeen *point* eighty-three”

The decimal point, you can see, is read as “and” in the first way, and “point” in the second way.

PROBLEMS

1. Write the following as decimals.
   - a. Four-tenths ________
   - b. 17-hundredths ________
   - c. Nine-hundredths ________
   - d. Twelve-thousandths ________
   - e. 72 ten-thousandths ________
   - f. Seven and three-hundredths ________
   - g. Fifty-three and two ten-thousandths ________
   - h. Twenty-nine and ninety-nine thousandths ________
2. Write each of the following as words:
   - a. .2 ________________________
   - b. .84 ________________________
   - c. .621 ________________________
   - d. 3.07 ________________________
   - e. .721 ________________________
   - f. 4.52 ________________________
   - g. 36.0009 ________________________
   - h. 8.372 ________________________
   - i. 6.06 ________________________
   - j. 4.208 ________________________

k. 16.075 ______________________________

l. .050 ______________________________

m. 1.0032 ______________________________

n. 10.4009 ______________________________

o. .998 ______________________________

p. 149.7 ______________________________

q. 35.485 ______________________________

r. $22.98 ______________________________

UNIT II – WORKING WITH METRIC MATH

Lesson 2 **Multiplying by 10 and 100**

Objective: You should be able to multiply by 10 and 100 by moving the decimal point.

One of the nicest things about using metric math is that changing from large units of measurement to small units (or the other way around) is so easy. Metric units go by 10's. So, we multiply or divide by 10, 100, 1000, etc. to change from one unit to another. It works like our money system. When we count money, the dollar is the basic unit.

1 dollar = 10 dimes, or 1 dime = .10 of a dollar

1 dollar = 100 cents, or 1 cent = .01 of a dollar

We convert (change) from larger units to smaller units by multiplying. Watch how it works.

Convert (change) 18 dollars to dimes. The dollar is the larger unit. It has 10 times the value of a dime. So we have 10 times as many dimes as dollars. In other words, we need to multiply 18 dollars by 10 to get the number of dimes.

To multiply by 10, move the decimal point ONE place to the RIGHT.

Where is the decimal point in the number 18? Since no decimal point appears in the number, we know that it is a *whole number,* and therefore it really has a decimal point *understood* at the *end* of the number.

$$\$18 = \$18.\swarrow$$

Then how can we move the decimal point one place to the right?

To do this we must write \$18 as \$18.0. It still means the same thing.

$$\$18 \times 10 = 18.\underset{\curvearrowright}{0} = 180 \text{ dimes}$$

Now, if we want to convert the 18 dollars to *cents,* we must remember that a dollar has 100 times the value of a cent. *To multiply by 100, we move the decimal point TWO places to the RIGHT.*

So, $\$18 \times 100 = 18.\underset{\smile}{00}{}_{\wedge} = 1800$ cents.

So we can call our $18 — —

18 dollars
or 180 dimes
or 1800 cents

PROBLEMS

1. A roll of dimes from the bank has $10 in it. How many dimes are there? __________

2. Your boss needs pennies for change. He sends you to the bank with 74 dimes to change for pennies. How many pennies will you have? __________

3. You have $54 to change into dimes. How many dimes will you have? __________

4. Change the $54 into pennies. How many pennies will you have? __________

5. Change $3.50 to dimes. __________

6. Change $3.50 to pennies. __________

7. Change $400 to dimes. __________

8. Change $14.57 to pennies. __________

9. Which way did we move the decimal point in problems 1 through 8? Why? __________

10. Do we multiply or divide when we change from larger units to smaller units? Why? __________

UNIT II – WORKING WITH METRIC MATH

Lesson 3 Dividing by 10 and 100

Objective: You should be able to divide by 10 or 100 by moving the decimal point.

In lesson 2 we changed larger money units to smaller units by multiplying by 10 or 100. Now we will *convert (change) from smaller units to larger units by dividing.* Watch how it works.

Convert (change) 300 dimes to dollars. The dime is the smaller unit. It is only 1/10th or .10 of a dollar, because there are 10 dimes in a dollar. Therefore we will have *fewer* dollars than dimes, and we will divide by 10.

We divide by 10 by moving the decimal point ONE place to the LEFT, like this:

300 dimes ÷ 10 = $30\underset{\smile}{0}.$ = 30.0 dollars = 30 dollars

Now, if we want to change 3,000 cents to dollars, we must remember that a cent is only 1/100th or .01 of a dollar, because there are 100 cents in a dollar. We must divide the 3000 cents by 100.

To divide by 100, we move the decimal point TWO places to the LEFT.

3,000 cents ÷ 100 = $30\underset{\smile}{00}.$ dollars = 30.00 dollars = 30 dollars

PROBLEMS

1. Change 4,782 cents to dollars. ________
2. Change 74 dimes to dollars. ________
3. Change 800 cents to dimes. ________
4. Change 670 cents to dimes. ________
5. Change 260 cents to dimes. ________
6. Change 1400 cents to dollars. ________
7. Express 1450 cents as dollars. ________
8. Express 2295 cents as dollars. ________
9. Which way (right or left)did we move the decimal point in problems 1 through 8? ________
10. Do we multiply or divide when we change from smaller units to larger units? Why? ________

UNIT II – WORKING WITH METRIC MATH

Lesson 4 Reading Metric Math

Objective: You should be able to tell how the size of metric measures can be told from the measurement name itself.

In the U.S. system of weights and measurements, changing from one unit to another is a long process of multiplying or dividing by hard numbers. For example, to change 50 ounces to pounds, we have to divide 50 by 16 (the number of ounces in a pound.)

$$\begin{array}{r} 3 \\ 16\overline{)\,50} \\ \underline{48} \\ 2 \end{array} \qquad \text{Answer: 3 lbs. and 2 ounces}$$

Working with metric math, however, is easy. The metric system is a *decimal system*. This means that every unit is 10 times as big as the next smaller unit, and 1/10th the size of the next larger unit. Therefore changing from one unit to another is as simple as moving a decimal point!

Watch how it works with money. The dollar is the basic unit for measuring money. The dime is .1 or 1/10th the value of a dollar. If a cent is .1 or 1/10th the value of a dime, it is also .01 or 1/100th the value of a dollar.

dime = 1/10 or .1 of a dollar
cent = 1/100 or .01 of a dollar
mill = 1/1000 or .001 of a dollar

The metric system uses *prefixes* on the unit name to tell you how large something is. Three of the prefixes are shown here. They may remind you of our money system:

deci = means 1/10 or .1
centi = means 1/100 or .01
milli = means 1/1000 or .001

If *deci* is 1/10th, what is it 1/10th of? The prefixes in the metric system are attached to the *basic unit* to show *what is being measured.* For example, the *meter* (MEE-ter) is the basic unit for measuring *lengths.*

So,

a decimeter = 1/10 or .1 of a meter
a centimeter = 1/100 or .01 of a meter
a millimeter = 1/1000 or .001 of a meter

Metric also uses three other prefixes. These have values greater than the base unit.

deka means 10 times
hecto means 100 times
kilo means 1000 times

So,

a dekameter = 10 meters
a hectometer = 100 meters
a kilometer = 1000 meters

Although metric uses all of these prefixes, and you will learn what they mean, in actual day-to-day use only a few of them are used very much.

Let's see if we can't find some ways to remember these prefixes. The trick is to connect each one in your mind with some way of remembering what number the prefix stands for.

deci – 1/10	This prefix comes from the Latin word "decimus," meaning one-tenth. It is the prefix upon which the *decimal* system is based. But how to remember it? This is a hard one, to be sure. But perhaps you have heard the word "*decimate,*" meaning to destroy a large part of, as "the epidemic decimated the population of the area." This word originally referred to a way of punishing a group of people, say, an army division that had rebelled. One out of every ten men (one-tenth) were selected by lot, and these men were killed! The division was *decimated.*
centi – 1/100	This is an easy one. One *cent* is one-hundredth of a dollar.
milli – 1/1000	We have a word "mill" in our money system, meaning one-tenth of a cent or one-thousandth of a dollar. We don't actually have the coin, but the word is used in taxation – a tax of so many *mills* per dollar of value. Electricians often use the words "*milliampere*" and "*millivolt,*" meaning one-thousandth of an ampere or a volt.
deka – 10 times	Do you know the word "*decade*"? It means a period of 10 years. If you find that word hard to remember, try thinking of "*decking*" a prizefighter for the count of 10!
hecto – 100 times	This prefix is not used very much, either in the metric system or in English words. But 100 is a "*heck* of a lot," especially if you've got 100 dollars to spend!
kilo – 1000 times	Here again the electricians have an advantage – they already know about the *kilocycle* (1000 cycles) and the *kilohertz,* equal to 1000 cycles per second. Our parents pay the electric company according to the number of *kilowatts* (1000 watts) used. But if electrical terms come hard, think of our government's capacity for *overkill* with nuclear bombs!

PROBLEMS

1. Which is larger?

   a. centimeter or meter ____________

   b. centimeter or millimeter ____________

   c. meter or kilometer ____________

   d. millimeter or kilometer ____________

   e. millimeter or meter ____________

2. If each unit below is .1 of the next larger unit, how many: (Be careful, it's tricky.)

   a. millimeters in 1 centimeter ________

   b. centimeters in 1 decimeter ________

   c. decimeters in 1 meter ________

   d. dekameters in 1 hectometer ________

   e. hectometers in 1 kilometer ________

3. If each unit below equals 10 times the next smaller unit, how many:

   a. kilometers in 1 hectometer ________

   b. hectometers in 1 dekameter ________

   c. dekameters in 1 meter ________

   d. meters in 1 decimeter ________

   e. decimeters in 1 centimeter ________

4. Define these measurements:

   a. kilometer ____

   b. meter ____

   c. centimeter ____

   d. millimeter ____

5. If you are usually rushed for time in the morning, which would you rather be – 1 kilometer away from your school or 500 meters? ____________

6. If milk is your favorite drink, which would you rather have – a liter of milk or a millileter?

7. One vitamin-C tablet contains a gram of the vitamin, and another contains 1000 milligrams. Which tablet has more vitamin C?

8. A centimeter is what part of a meter?

9 A table of food values listed all foods in 100-gram portions. Can you figure out another way of saying 100 grams?

10. A bill for electricity charged by the kilowatt-hour. How else could you say the same thing?

UNIT III – LINEAR MEASUREMENT

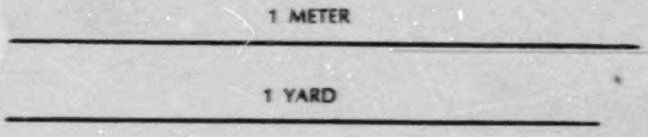
Lesson 1 Reading the Meter Stick

Objective: You should be able to take short measurements with a meter stick or ruler.

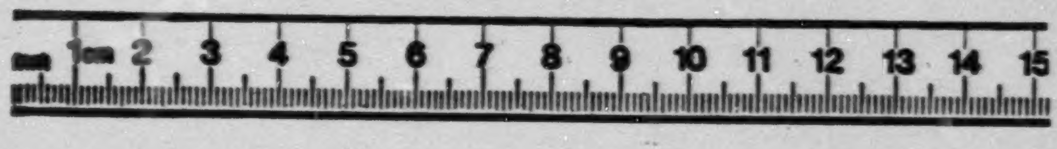
Taking measurements of things with a yardstick, tape, or ruler is far from easy. There are 3 feet in a yard, 12 inches in a foot, and each inch is divided into halves, quarters, eighths, etc. Mistakes are very likely to creep in somewhere and goof up your measurement.

Taking measurements in metric is much, much simpler. Remember – metric is all based on the number 10.

First, let's see how long the standard measure of length *(linear measure)* is. Your instructor will show you a meter stick and a yardstick. You will see that the meter is a little longer than a yard. Here is a picture that shows the difference.

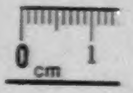


Now let's look more closely at the *meter stick.* One end of it looks like this:

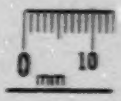


Each one of those lines across the stick stands for 1/100 of a meter. But we already know what 1/100 of a meter is. It is a *centimeter.*

Now let's look more closely at the *centimeter.* The distance from 0 to 1 in this picture is one centimeter.

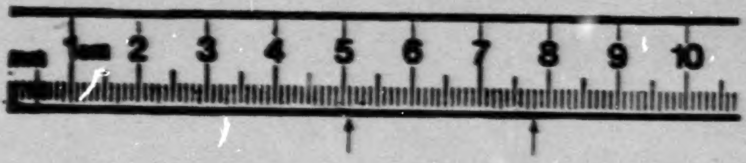


The centimeter is itself divided into 10 parts. Do you remember the name of the next smaller metric measurement? . . . . If you said *millimeter,* you were right. The distance between each two lines is one millimeter, and the whole centimeter is equal to 10 millimeters.



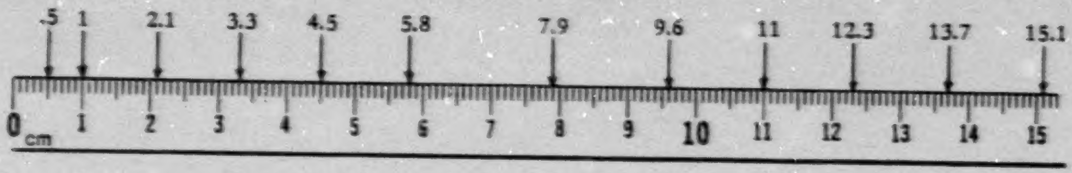
The fact that we are dealing with numbers that go by tens and hundreds means that we can *read a measurement off directly in decimals.*

For example, suppose we measured something and found that it came to 5 centimeters and 1 millimeter. We know that 1 mm = .1 cm; so we would simply say the measurement was 5.1 cm.



Similarly, if the measurement came to 7 cm and 8 mm, we could read if off directly as 7.8 cm.

Here is another picture of the first part of a meter stick. Notice how the different measurements are read.



All measurements, as you know, are *approximations.* We use the *degree of accuracy* that the situation calls for. If we are measuring a window for drapes or curtains, it would be accurate enough to measure it to the *nearest whole centimeter.* If we were measuring the same window for a window shade to fit into brackets on the inside of the frame, we would surely need an accuracy to the *nearest tenth of a centimeter* – that is, to the *nearest millimeter.* If we were manufacturing window locks, we might want the mating parts accurate to the *nearest tenth of a millimeter.* If we were manufacturing screws and bolts, we would probably have to have our measurements accurate to *hundredths of a millimeter.*

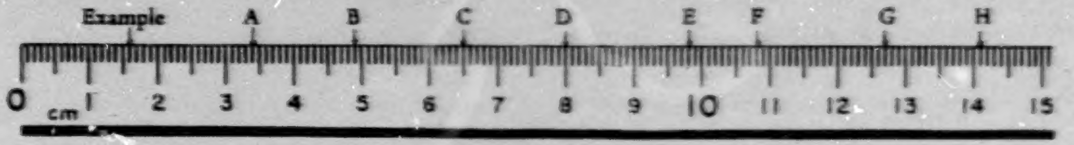
Right now, as we get used to working with metric, we will use ordinary tapes and rulers, and we will take fairly rough measurements.

To help you think in metric terms, here are three common metric measurements.

A *dime* is about 1 millimeter thick.
A *piece of chalk* is about 1 centimeter thick.
The distance from a doorknob to the floor is about 1 meter.

PROBLEMS

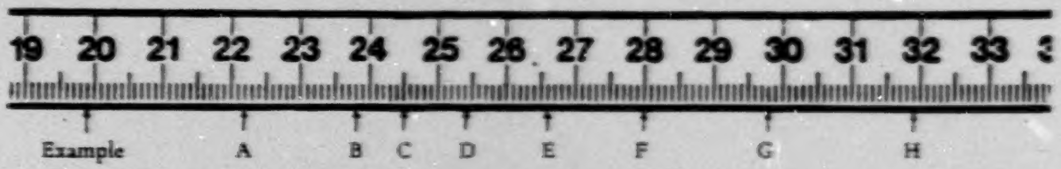
1. Write in the number of centimeters and millimeters for points A through H as shown on this metric ruler. Then express each one in centimeters, using a decimal.


Example
A
B
C
D
E
F
G
H
0
cm
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Example: 1 cm 6 mm or 1.6 cm

A. _____ cm ___ mm or _____ cm
B. __________ or _______
C. __________ or _______
D. __________ or _______
E. __________ or _______
F. __________ or _______
G. __________ or _______
H. __________ or _______

2. Now write the number of centimeters for A through H on this section of a meter stick.


19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
3
Example
A
B
C
D
E
F
G
H

Example: 19.9 cm

A. _____ cm
B. _______
C. _______
D. _______
E. _______
F. _______
G. _______
H. _______

3. Using a meter stick or ruler, give the measurements of the following, correct to the nearest tenth of a centimeter.

A. The width of this math book __________
B. The height of this math book __________
C. The distance from the line of B in problem 1 to the line of H __________
D. The distance from the line of A in problem 2 to the line of D __________
E. The length and width of a floor tile in the classroom __________
F. The diagonal of a floor tile, from corner to corner __________
G. The dimensions of a single window pane __________

4. Give these measurements correct to the nearest whole centimeter.

A. The width of a file cabinet ____________

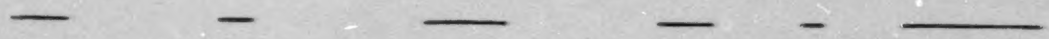
B. The depth of a bookcase ____________

C. The height from the floor to the top of the teacher's desk ____________

5. Measure the following, giving your answers correct to the nearest *millimeter.*

A. The thickness of this math book ____________

B. These distances (write on the lines)



C. The dimensions of the light switch on the wall ____________

D. The length of your shortest fingernail ____________

E. The length of your longest fingernail ____________

UNIT III – LINEAR MEASUREMENT

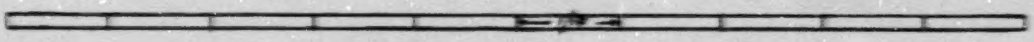
Lesson 2 Measuring Longer Distances

Objective: You should be able to take metric measurements longer than a meter.

You may need to take measurements of longer distances from time to time. You might have to order lumber for a job, or get the size of a room in order to buy the right amount of carpeting, measure property for fencing, etc.

There are folding metric rulers and metric tapes that you can use to take these measurements. Once again, they are much easier to use than tapes marked in yards, feet, and inches.

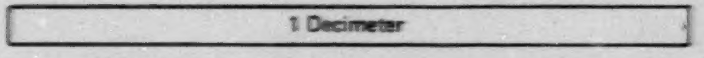
Here is a picture of a meter stick.



1 Meter

The meter stick has been divided into 10 parts. Do you remember the name of the measure that is 1/10 of a meter? . . . If you said *decimeter*, you were right. Some metric tapes and folding rulers use different colors to mark off the decimeters, but many do not.

Here is the actual length of a decimeter.



Suppose you took a measurement that came to 2 meters and 1 decimeter. Since the decimeter equals 1/10 (or .1) of a meter, you could give the measurement immediately as 2.1 meters.

Or if a measurement came to 7 meters and 8 decimeters, you could give it immediately as 7.8 meters.

Most measurements are read from the tape, however, not in meters and decimeters (tenths), but in meters and centimeters (hundredths). These measurements are just as easy to read off.

Suppose you found that your measurement came to 3 meters and 26 centimeters. You could just call it 3.26 meters.

Or it might come to 11 meters and 85 centimeters. Easy! That's 11.85 meters.

You and your fellow students can measure the classroom and get its length, width, and height. Take the measurements first in meters and centimeters, and then in meters and hundredths. Get each measurement correct to the *nearest whole centimeter* or hundredth of a meter.

Length: ___ m ___ cm or ___ m

Width: ___ m ___ cm or ___ m

Height: ___ m ___ cm or ___ m

PROBLEMS

1. Give the following measurements in terms of meters:

Example: 6 m 7 dm 6.7 m

A. 10 m 2 dm ___ m

B. 3 m 9 dm ___ m

C. 12 m 5 dm ___ m

D. 142 m 8 dm ___ m

E. 6 dm ___ m

2. Give the following measurements in terms of meters:

Example: 14 m 12 cm 14.12 m

A. 4 m 80 cm ___ m

B. 10 m 29 cm ___ m

C. 9 m 4 cm ___ m

D. 26 m 92 cm ___ m

E. 45 cm ___ m

3. With a partner, take the following measurements in meters and centimeters, correct to the nearest whole centimeter. Give your answer in terms of meters, as in problem 2 above.

A. The inside height of the door opening in your classroom ___

B. The length of the chalkboard ___

C. The length of the teacher's desk ___

D. ___

E. ___

For Class Discussion

1. Would a carpenter measure a door to the nearest meter, decimeter, centimeter, or millimeter? Why?

2. Would a dressmaker use meters, decimeters, centimeters, or millimeters to measure a person for clothes? Why?

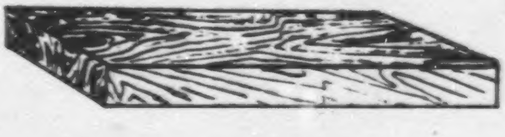
3. Would the dressmaker purchase cloth in terms of meters, decimeters, centimeters, or millimeters?

4. Would a machinist use meters, decimeters, centimeters, or millimeters to measure bolts? Why?

5. What unit of measure would you use for:

    a. a window frame
    b. floor tile
    c. an air duct
    d. distances between towns
    e. garden fencing
    f. thickness of a plate or cup
    g. spark-plug gap
    h. height of a mountain
    i. a road sign
    j. tablecloth

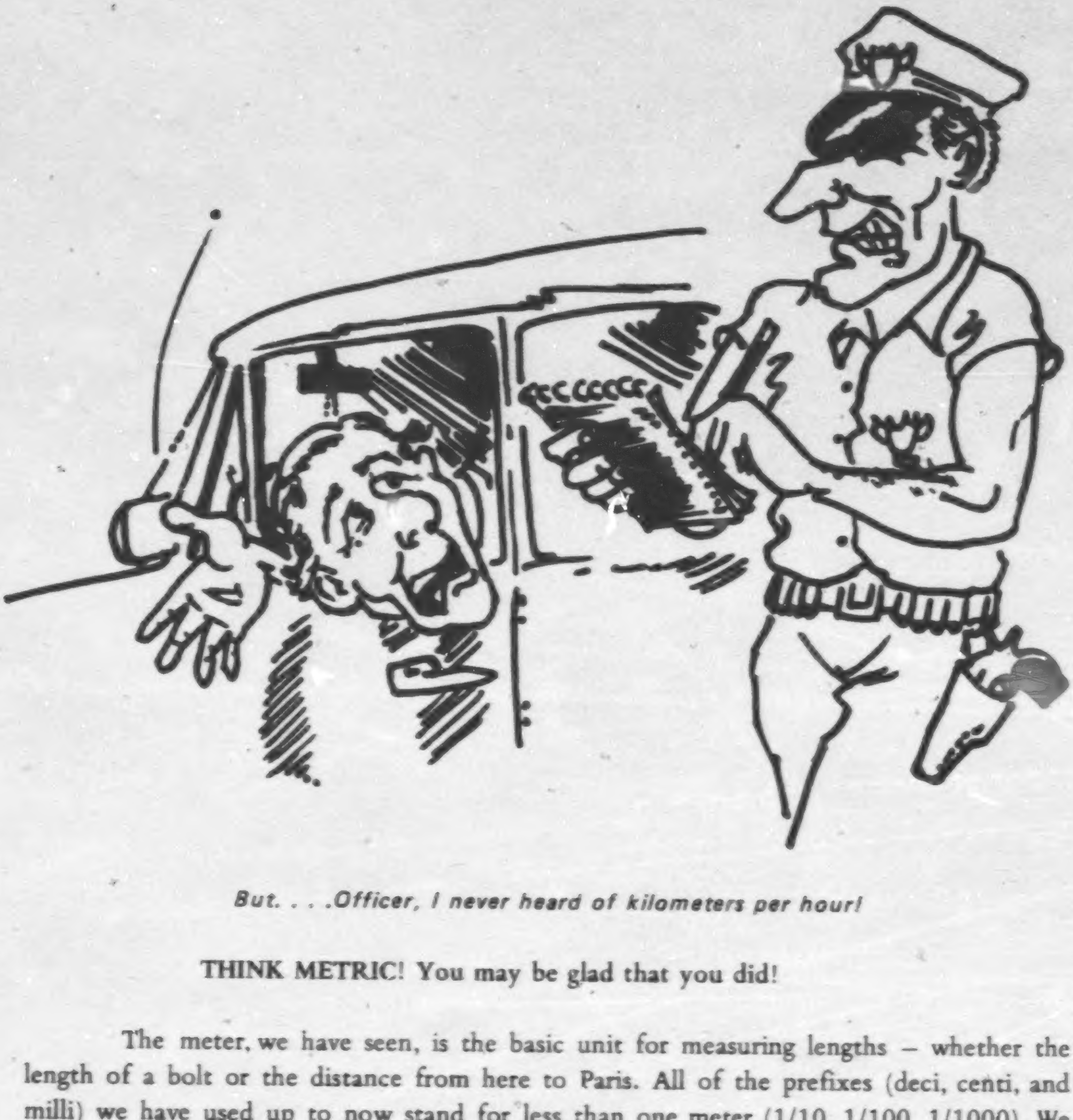
6. Measure this board. What unit of measure did you use? What unit of measure would you use for a longer board?



Lesson 3 **Kilometers**

Objectives: You should know how long a kilometer is.

You should know the names and meanings of the other metric units longer than a meter.



But. . . .Officer, I never heard of kilometers per hour!

THINK METRIC! You may be glad that you did!

The meter, we have seen, is the basic unit for measuring lengths – whether the length of a bolt or the distance from here to Paris. All of the prefixes (deci, centi, and milli) we have used up to now stand for less than one meter (1/10, 1/100, 1/1000). We need different prefixes when measuring longer distances. Let us review what they are.

The prefix deka means "10 times." A dekameter is equal to 10 meters.

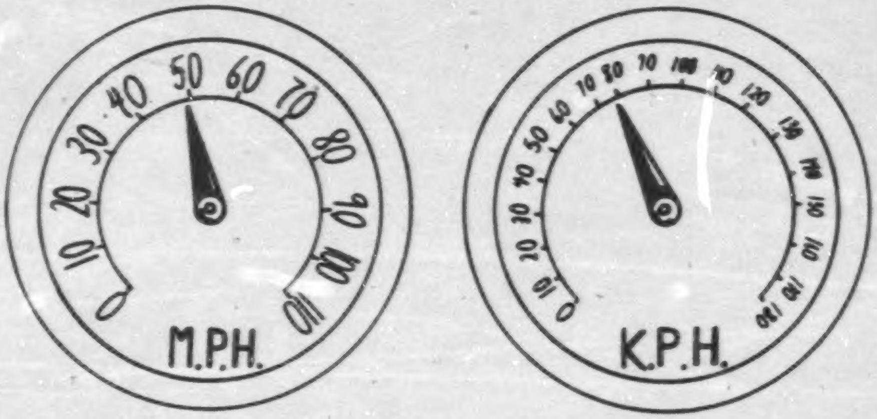
The prefix hecto means "100 times." A hectometer is equal to 100 meters.

Neither of the above units is used very much. What *is* used a great deal is "kilometer." (Unlike the other metric words, "kilometer" is usually pronounced "kil LOM e ter.")

Kilo means "1,000 times." A kilometer is equal to 1,000 meters. The kilometer is used to measure long distances.

For Class Discussion

1. A kilometer is equal to about .6 mile. Since it is a *smaller* distance than a mile, will there be more or fewer kilometers than miles in any given distance?
2. Look at the two speedometer dials below. Are the speeds about the same or different? Why?



3. Will a car that gets 25 miles per gallon of gas get more or fewer kilometers per gallon?
4. Which is longer, a racing track that covers a mile or one that covers a kilometer?
5. On a hike, would you be nearer home if you had two more miles to go or two more kilometers?
6. How many meters in one kilometer?
7. The class will estimate the distances in kilometers between several locations that are more than 1 kilometer apart.

PROBLEMS

1. Unscramble these metric prefixes:

Scrambled	Metric	Meaning
keda	______	________________
tohec	______	________________
loki	______	________________

2. What are the most common metric units for measuring distances? Give at least one example of a length that you would measure for each of these four units.

A. Standard of measurement: ________________ Example: ____________

B. Smaller measurements: ________________ Example: ____________

C. Very small measurements: ________________ Example: ____________

D. Long distances: ________________ Example: ____________

UNIT III – LINEAR MEASURE

Lesson 4 **Converting From One Unit to Another**

Objective: You should be able to convert (change) a measurement from one metric unit to another.

Many times when you work a problem you end up with a unit that it not really suitable. For example, if you wanted to buy favors for a party for 80 people, and each favor cost 29 cents, you'd want to know the total cost.

$$29 \text{ cents} \times 80 = 2320 \text{ cents}$$

Of course, what you really want to know is the number of *dollars*. As we have seen, since our money system is a decimal system (like the metric), all we have to do to change from cents to dollars is move the decimal point.

Since there are 100 cents in a dollar, the dollar is the *larger* unit, and we will have *fewer* dollars than we have cents. This tells us that we must *divide*. We divide by 100 by moving the decimal point to the left.

$$2320 \text{ cents} \div 100 = 23\underset{\smile}{20} = \$\,23.20$$

Converting metric measurements is just as easy as converting cents to dollars or dollars to cents.

Below is a table you can refer to if you forget how much each unit stands for. Although all the units from kilometer to millimeter are shown, the most commonly used units are marked with a *.

Value of Metric Linear Units

Linear Unit	Symbol		Length in Meters
* 1 kilometer	km	=	1000 meters
1 hectometer	hm	=	100 meters
1 dekameter	dam	=	10 meters
* 1 meter	m	=	Basic Linear Unit
1 decimeter	dm	=	.1 meter
* 1 centimeter	cm	=	.01 meter
* 1 millimeter	mm	=	.001 meter

Here is a problem for the class to work out together.

A room measures 20.4 meters long

(a.) How many dekameters long is it?

(1) One dekameter equals 10 meters.
(2) A dekameter is therefore the *larger* measure.
(3) Therefore there will be *fewer* dekameters than meters.
(4) We therefore *divide:*
    20.4 ÷ 10
    Move the decimal point *one* place to the *left.*
    20.4 ÷ 10 = 20.4 = 2.04 dekameters

(b.) How many centimeters long is the room?

(1) One centimeter equals 1/100 (.01) of a meter.
(2) One meter is therefore equal to 100 centimeters.
(3) The centimeter is the *smaller* measure.
(4) Thus there will be *more* centimeters than meters.
(5) We therefore *multiply:*
    20.4 X 100
    Move the decimal point *two* places to the *right.*
    20.4 X 100 = 20.40 (We have to add a zero to get two places.)
    = 2040 centimeters

(c.) How many kilometers long is the room?

(1) One kilometer equals 1000 meters.
(2) A kilometer is therefore the *larger* measure.
(3) Therefore there will be *fewer* kilometers than meters.
(4) We therefore *divide:*
    20.4 ÷ 1000
    Move the decimal point *three* places to the *left.*
    20.4 ÷ 1000 = .0204 (We have to add a zero to get three places.)
    = .0204 kilometers

Look at the same room again; we can now make a chart showing its length in seven different units of metric linear measure.

The room is .0204 kilometers
or .204 hectometers
or 2.04 dekameters
or 20.4 meters
or 204 decimeters
or 2,040 centimeters
or 20,400 millimeters.

PROBLEMS

1. Measure your classroom in meters (to two decimal places). Convert the measurements by multiplying or dividing, as follows:

A. Length: ________ meters; ________ kilometers; or________ centimeters

B. Width: ________ meters; ________ kilometers; or________ centimeters

C. Height: ________ meters; ________ kilometers; or________ centimeters

2. Go back to page 16 and convert each measurement in problem 3 as indicated:

A. _____ cm ➡ _____ mm

B. _____ cm ➡ _____ mm

C. _____ cm ➡ _____ mm

D. _____ cm ➡ _____ mm

E.(1) _____ cm ➡ _____ m

E.(2) _____ cm ➡ _____ m

F. _____ cm ➡ _____ m

G.(1) _____ cm ➡ _____ m

G.(2) _____ cm ➡ _____ m

3. Convert each measurement in problem 5 on page 17 from millimeters to centimeters.

A. _____ mm ➡ _____ cm

B. (1) _____ mm ➡ _____cm

C. _____ mm ➡ _____cm

D. _____ mm ➡ _____cm

E. _____ mm ➡ _____cm

4. Convert each measurement in problem 4 on page 17 from centimeters to meters.

A. _____ cm ➡ _____ m

B. _____ cm ➡ _____ m

C. _____ cm ➡ _____ m

5. Convert each measurement in problem 3 on page 19 from meters to centimeters.

A. _____ m ➡ _____ cm

B. _____ m ➡ _____ cm

C. _____ m ➡ _____ cm

D. _____ m ➡ _____ cm

E. _____ m ➡ _____ cm

6. Convert the following measurements as indicated.

A. 3.16 meters to centimeters __________cm

B. 1572 centimeters to meters __________m

C. 1400 decimeters to meters __________m

D. 21,425 meters to kilometers __________km

E. 338 centimeters to meters __________m

F. 4936 millimeters to meters __________m

G. 2.495 kilometers to meters __________m

H. .16 meters to centimeters __________cm

I. .072 meters to millimeters __________mm

J. 143 decimeters to meters __________m

7. Convert the following measurements.

A. 2.2 meters to centimeters __________cm

B. 149 millimeters to centimeters __________cm

C. .72 meters to millimeters __________mm

D. .04 meters to millimeters __________mm

E. 42 meters to kilometers __________km

F. 16 centimeters to meters __________m

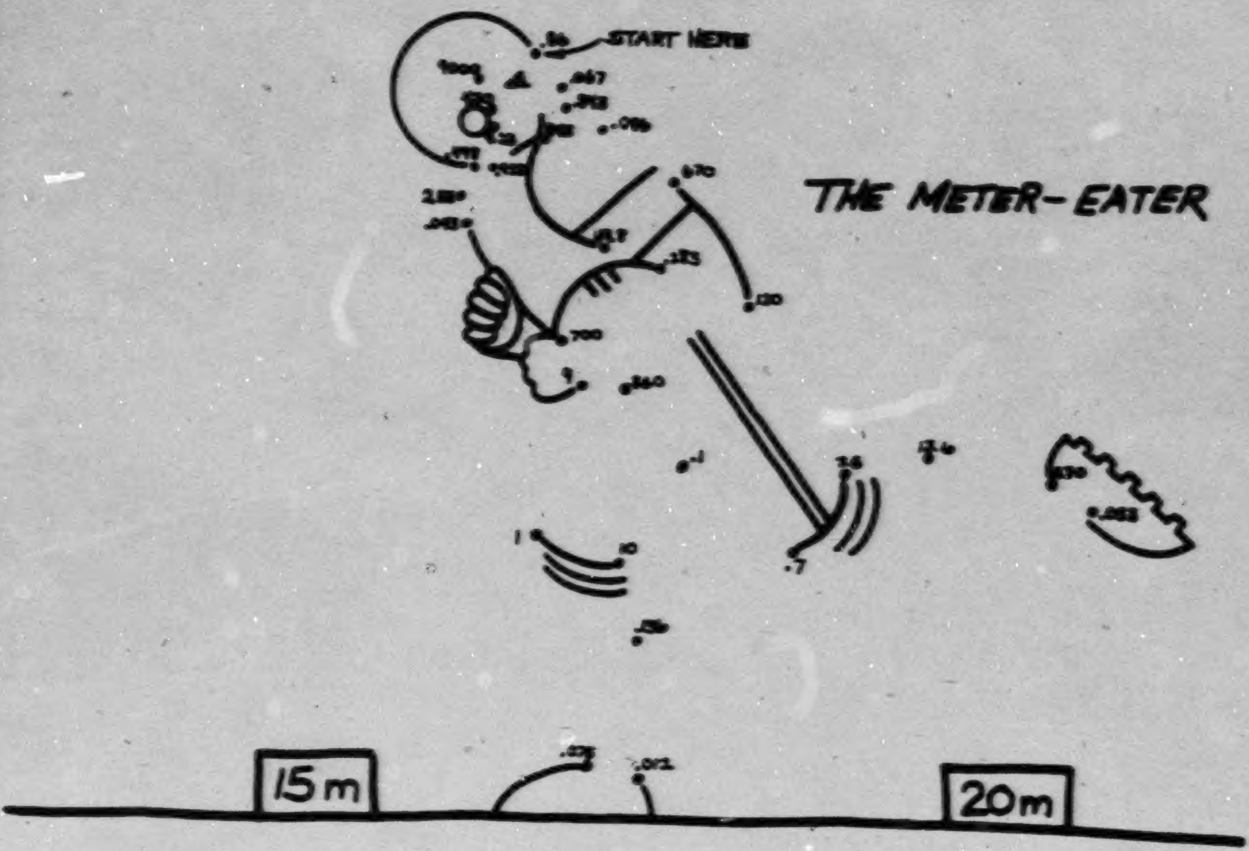
G. 35 meters to decimeters __________dm

H. 1000 meters to kilometers ________ km

I. 9 centimeters to meters ________ m

J. 2 meters to millimeters ________ mm

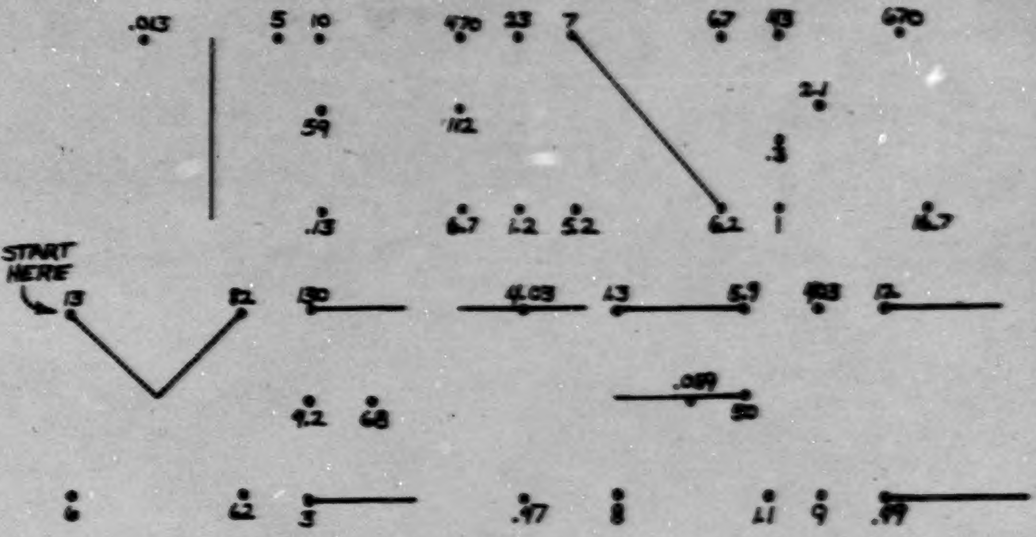
8. Now see how quickly you can complete this picture by connecting the answers in order.


.86
START HERE
.067
670
120
700
9
.1
THE METER-EATER
1
10
.7
15m
20m

1. 8.6 mm = .86 cm
2. 9 m = _____ mm
3. .43 km = _____ m
4. 6.7 cm = _____ m
5. 843 mm = _____ m
6. .923 cm = _____ mm
7. 498 m = _____ km
8. 28.3 mm = _____ cm
9. 4300 cm = _____ km
10. 923 m = _____ km
11 .843 m = _____ mm
12. 86000 mm = _____ km
13. .0067 km = _____ cm
14. 4.98 cm = _____ mm
15. 28.3 cm = _____ m
16. 7 m = _____ cm
17. .9 cm = _____ mm
18. .00012 km = _____ mm
19. 75 mm = _____ cm
20. .0136 km = _____ m
21. 5.3 m = _____ cm
22. 53 mm = _____ m
23. .007 m = _____ cm
24. .86 m = _____ mm
25. .1 cm = _____ mm
26. .75 m = _____ km
27. 1200 cm = _____ km
28. 136000 mm = _____ km
29. .1 m = _____ cm
30. 1 mm = _____ cm

9. BRAIN TEASER

Connect the answer to problem (a) to the answer to problem (b) for each of the 20 double problems below. Use the margins for figuring. *Watch out for changes in units!*



.013
5
10
470
23
7
67
83
670
2.1
59
112
.3
.13
6.7
1.2
5.2
6.2
1
16.7
START HERE
13
82
130
41.03
43
5.9
483
12
.089
9.2
68
50
6
6.2
3
.97
8
1.1
9
.99

	(a)				(b)		
1.	8 m + 5 m =	______	m	&	9 m - 3 m =	______	m
2.	8 m + 5 m =	______	km	&	17 cm - 12 cm =	______	cm
3.	8 cm + 5 cm =	______	m	&	43 km - 33 km =	______	km
4.	8 cm + 5 cm =	______	mm	&	7 mm - 4 mm =	______	mm
5.	436 m + 764 m =	______	km	&	32 cm - 9 cm =	______	cm
6.	8 cm + 2 mm =	______	mm	&	9 cm - 28 mm =	______	mm
7.	6 cm + 7 mm =	______	mm	&	9 cm - 28 mm =	______	cm
8.	6 cm + 7 mm =	______	cm	&	1 km - 530 m =	______	m
9.	4 m + 3 cm =	______	m	&	1 km - 530 m =	______	km
10.	4 m + 3 cm =	______	cm	&	9.8 m - 0.8 m =	______	m
11.	5 cm + 20 mm =	______	cm	&	9 m - 380 cm =	______	m
12.	4 cm + 3 mm =	______	mm	&	0.7 m - 69 cm =	______	cm
13.	9 mm + 4 mm =	______	cm	&	27 cm - 19 cm =	______	cm
14.	10 m + 200 cm =	______	m	&	52 cm - 3 cm =	______	m
15.	365 cm + 225 cm =	______	m	&	8 cm - 3 cm =	______	mm
16.	5 cm + 9 mm =	______	mm	&	14 cm - 28 mm =	______	mm
17.	356 mm + 324 mm =	______	cm	&	7 cm - 28 mm =	______	cm
18.	49 cm + 18 cm =	______	mm	&	11 mm - 8 mm =	______	cm
19.	38 m + 21 m =	______	km	&	3.9 mm - 2.8 mm =	______	mm
20.	8 mm + 13 mm =	______	cm	&	18 m - 1.3 m =	______	m

10. MIX AND MATCH PUZZLE I

(Linear Measure)

On the next page you will see the sheet you are going to work on.

Cut the squares on this page apart. You are going to arrange these squares on the next page so that every measurement *has the same value* as the measurement adjacent (right next) to it. See the example below. When you are sure your solution to the puzzle is correct, paste or tape your squares down.

57 km .01 m 4 m .23 km	23 mm 4 mm 400 m 5.7 km	.057 km 1000 cm 40 mm 230 dm	570 mm 10 cm .4 mm 230 mm
5.7 m .01 m .4 cm 57 mm	.023 hm 400 cm .1 cm 5.7 mm	230 cm 1 m 400 mm 23 cm	23 m 4 cm 10 dm 57 cm
230 m 400 km 4000 m 57 dm	5700 m .04 m 10 dm .057 cm	2.3 dm 1 mm 4 mm 57 m	23 cm .4 m .04 mm 570 km
5.7 cm .1 mm 40 mm 230 km	.57 cm 4 km 10 m 2.3 cm	23 m .4 km 1 dm 2300 mm	.057 mm .4 cm .01 mm .023 km

Example: .4 cm | 4 mm 400 m | .4 km

5.7 km

5700 m

SOLUTION to MIX and MATCH PUZZLE I

57 km .01 m 4 m .23 km			

UNIT III – MEASURING LENGTHS

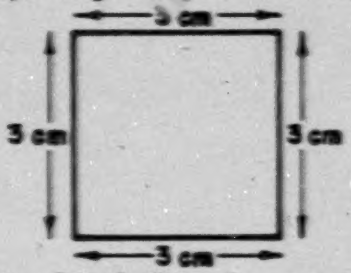
Lesson 5 **Calculating Perimeters**

Objective: You should be able to measure and calculate the perimeters of squares, rectangles, and triangles.

The perimeter is the distance around the outside of an object. It is always a length or linear measurement. For example, we measure the perimeter for:

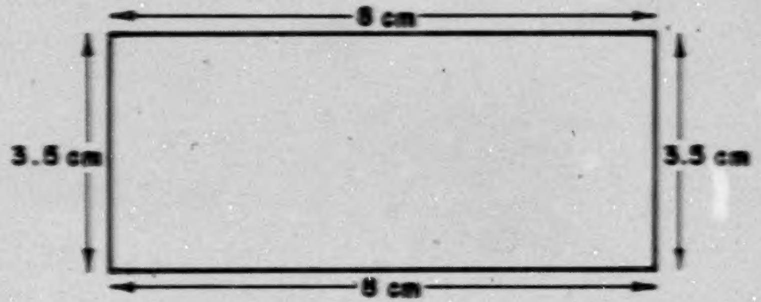
- The length of fence to go around a field, a garden, or a home lot.
- The length of molding to go around a room, a table, or a picture frame.
- The distance around areas for edgings, paths, roads, etc.

Perimeters are usually easy to measure. You can measure all the way around an object. However, if the object is a square, it is usually easier to measure one side and multiply by 4 to get the perimeter.

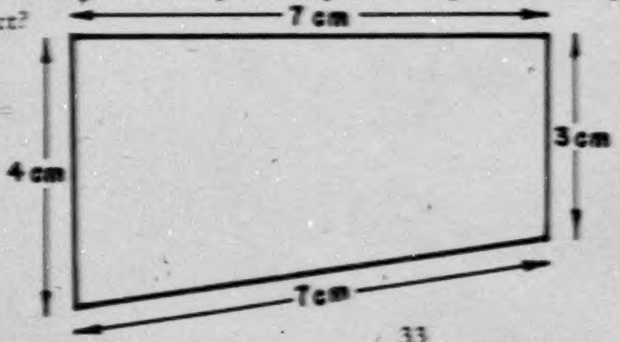


For example, the perimeter of this square is 12 centimeters.

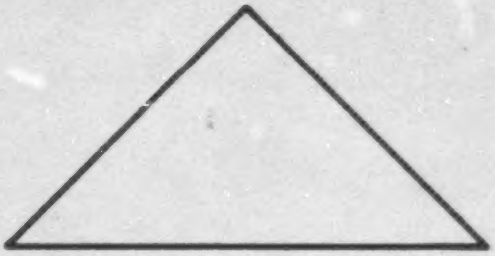
Now, let's look at the perimeter of a rectangle. What is the perimeter of this rectangle?



Not all objects are a perfect square or a perfect rectangle. What is the perimeter of this object?



What is the perimeter of this triangle? Use a metric ruler to measure the lengths of the sides.



Now, let's find the perimeters of some objects in the classroom.

What is the perimeter of the top of your desk (or your teacher's desk)? Should your measurements be in millimeters, centimeters, or meters? Why?

What is the length of the molding around the chalkboard in your classroom?

What is the length of the baseboard in your classroom?

PROBLEMS

1. A carpenter was to install a dado molding around a room that measured 5.4 meters by 7.2 meters. How much molding did he need? ________

2. A machinist had to drill small holes all around a metal plate that was 31 cm long and 15 cm wide. If the holes were to be drilled 1 cm apart (center to center), how many holes would be required? ________

3. A farmer's field, rectangular in shape, measured 210 meters by 375 meters. How much fencing would he need to enclose the entire field? (Give your answer in two different metric units.) ________

   ____

4. A housewife wanted to decorate a tablecloth with a fringe edging. If the tablecloth was 1.3 meters square, how much fringe would she have to buy?

5. A tarpaulin had to be reinforced along all four edges. If its dimensions were 3.6 meters by 4.5 meters, how much reinforcing material was needed?

6. How much picture-frame molding is needed for a picture 78 cm by 51 cm? (Give your answer in two different metric units.)

7. A mason was going to put a brick edge around a terrace that measured 6.5 meters by 8.9 meters. What distance would he have to figure on?

   If each brick (standing on end) and its mortar came to 8 cm, how many bricks would be required for this job?

8. An upholsterer was to decorate the edge of an upholstered piano bench with ornamental nailheads placed 2 cm apart (center to center). If the bench measured 38 cm by 75 cm, how many such nails would he have to buy?

9. A swimming pool measured 6.8 meters by 23 meters. How long would the perimeter be?

   How many brick, laid end to end, would be needed to edge the pool if each brick and its mortar came to 22 cm?

10. How much veneer edging is needed for a table 82 cm by 2.24 meters?

    How much would be needed for 20 such tables?

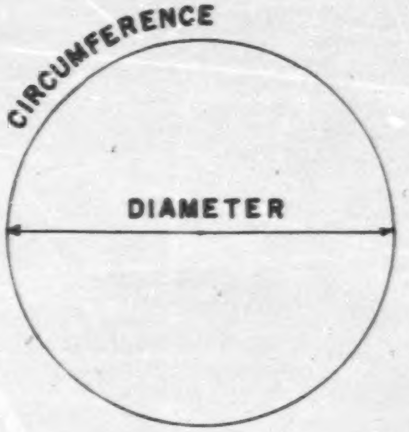
UNIT III – MEASURING LENGTHS

Lesson 6 — Calculating Circumferences

Objective: You should be able to compute the circumference of a circle when given either the diameter or the radius.

The distance across a circle through its center is called the *diameter* of the circle.

The perimeter of a circle has a special name. It is called the *circumference.* Measure any circle – a tire, a grinding wheel, a dish, a circular path – and you will find that *the circumference is always a little over 3 times the diameter of the circle.*



A more exact figure for this relationship is 3.1416 times the diameter. Depending on how accurate we need to be in finding a circumference, we may use the figure of 3.14 or 3.1416.

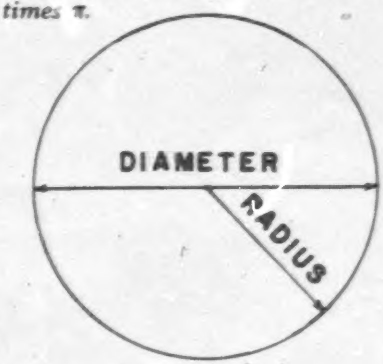
Scientists sometimes use even a more accurate figure. This number, 3.1416, has been given a name, the Greek letter π or pi. We write the above relationship in a sort of shorthand, called a formula. It is

$$\boxed{C = \pi D}$$

This stands for : Circumference equals π times the diameter.

With other members of your class, measure the diameters and circumferences of at least five circles, as accurately as you can. Some suggestions of things to measure are pulleys, grinding wheels, clock faces, circular tables, and any other circular objects in your shop or lab. Divide each circumference by the diameter. The more accurate your measurements, the closer you will come to pi, or 3.1416. See how accurate you can be.

The radius of a circle is the distance from the center to the curve of the circle. Since the radius is equal to one-half the diameter, *the circumference is also 2 times the radius times* π.



We write this as a formula also.

$$\boxed{C = 2\pi r}$$

Do you see why this formula follows from the other one?

When doing the problems below, round off your answers to the *same number of decimal places as there are in the given measurement.* Then, if appropriate, convert the answer to the next larger decimal unit.

PROBLEMS

1. Find the circumference of the circles below when given the diameter, D. (Use π = 3.14.) For your answer, use the most appropriate decimal unit.

   A. D = 24 mm C = ______

   B. D = 36 mm C = ______

   C. D = 4.1 cm C = ______

   D. D = 2.04 cm C = ______

   E. D = 165 cm C = ______

2. Find the circumference of a circle when given the radius, r. (Use π = 3.14.) For your answer, use the most appropriate decimal unit.

   A. r = 36 mm C = ______

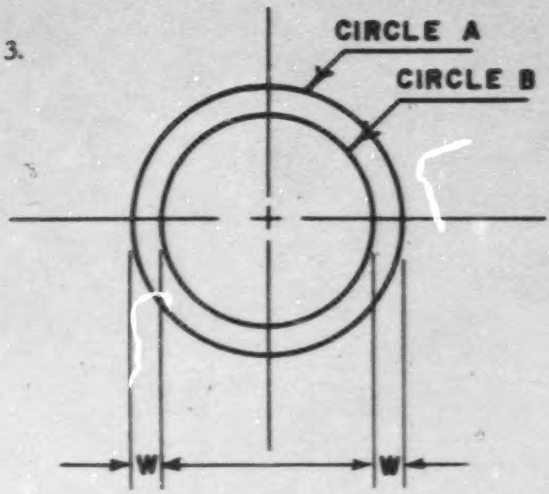
   B. r = 38.1 mm C = ______

   C. r = 20 mm C = ______

   D. r = 12.3 cm C = ______

   E. r = 7.05 cm C = ______

3.



In the pulley illustrated to the left: The radius of circle A is 52 mm, and the distance W is 8 mm. Find the radius of circle B. Then find the circumference of circle B. (Use π = 3.1416.)

r of B = __________

C of B = __________

4. If the diameter of circle B in problem 3 is 4.2 *cm* and W = 5*mm*, find the diameter and circumference of circle A. (Use π = 3.14.)

d of A = __________

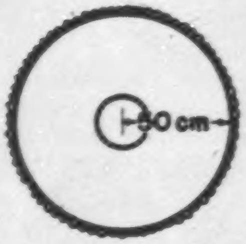
C of A = __________

5. A landscape gardener had to lay out a circular bed that was to be 9 meters across. It was to be edged with tiles. What was the distance that had to be edged? If each tile took 10 centimeters, how many tiles would be needed? (Use the less exact value of pi.)

Distance __________

No. of tiles __________

6.

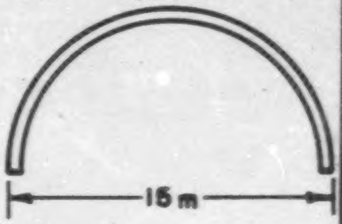


A dress designer designed a skating outfit having a perfectly circular skirt with a radius of 50 cm. About how much edging would such a skirt require?

____

7. A mason had to estimate the number of bricks for a semicircular wall 15 m across. What was the length of the wall? (Hint: Find the length of a full circle first. A semicircle is half a full circle.) (Which value of π would be appropriate here?)

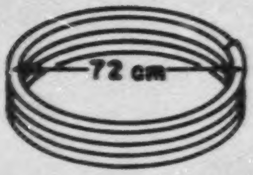
____



8. How many bricks were needed for a single course if each brick and its mortar took 21 cm?

____

9.



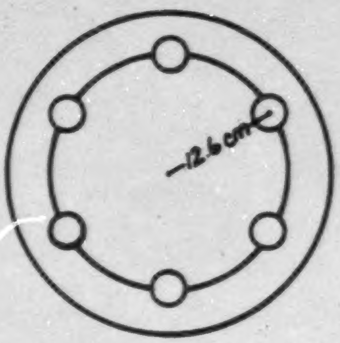
A plumber had a coil of copper tubing and needed to know how long it was. The distance across the coil was 72 cm, and there were four complete circles of tubing. About how many meters of tubing did he have?

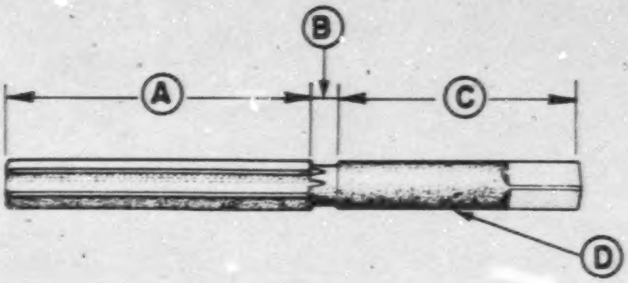
______

10. A machinist had to lay out 6 holes equally spaced on a bolt circle 12.6 cm in radius. What was the circumference of the bolt circle? (Which value for π should you use?) How far apart, center-to-center, were the holes?

______

______



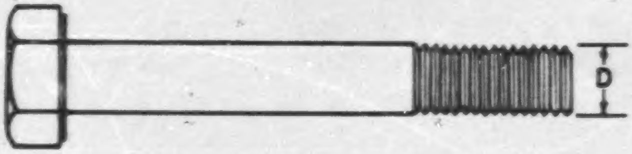


11. On the above reamer, measure the lengths of A, B, and C. What is the diameter of D? (Use the most appropriate unit.)

A. ______ B. ______ C. ______ D. ______

12. For the same reamer, compute the circumference of D, using the most exact figure you know for π.

______



13. What is the total length of this bolt in millimeters?

______

In centimeters?

______

14. What is the diameter (D) of the threads on the bolt in millimeters?

______

In centimeters?

______

15. What is the circumference of the unthreaded portion of the bolt?

______

For Class Discussion

1. In what trades would you be likely to use 3.1416 for π?

2. In what trades would you be likely to use 3.14 for π?

3. Would you ever be likely to use just "3 plus a little more"?

4. Give examples of diameter measurements that are extremely accurate; that are moderately accurate; that are rough approximations.

5. What happens to each of these when multiplied by 3.14 or 3.1416? Are the answers really as accurate as they seem to be?

6. If a diameter is 22.1 centimeters, multiplying by 3.14 gives 69.394 cm. According to our rule (p. 37), how should the answer to given? What is the reason for this rule?

7. Discuss rounding off decimals. Have the class develop a rule that applies in all cases.

UNIT IV – AREA MEASUREMENTS

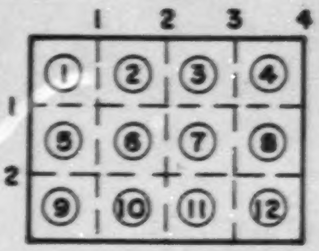
Lesson 1 — Defining Square Measure

Objectives: You should be able to define square measure and to list several uses of square measure.

We have all measured the length (linear measure) of things like boards, walls, walks, etc. Sometimes we need to know the area or square measure of fields, walls, floors, etc. Farmers, construction workers, rug installers, and many other people use square measure in their work. The area, or square measure, of your lawn is needed when applying fertilizer or other lawn chemicals. If you are painting your bedroom, you will use the square measure of the wall area to decide how much paint to buy.

The units for square measure are also squares – square centimeters, square meters, etc.

Look at the rug below. It is 3 meters wide by 4 meters long.



How many square meters of area does the rug cover? Each of the squares equals 1 square meter. Count up the squares yourself. A 3-meter by 4-meter rug covers 12 square meters of area.

We can also find the square measure, or area, by multiplying the length by the width. The rug is:

3 meters wide by 4 meters long

$$3 \text{ m} \times 4 \text{ m} = 12 \text{ m}^2$$

Now, what is the number of square centimeters on this page? (It might be easier to measure the cover of the book.) Did you measure in centimeters or millimeters? Why?

For Class Discussion

List five occupations that use square measure. List one use of square measure for each of the five occupations.

PROBLEMS

1. What is the area of this rectangle? Measure carefully with your ruler. Would you give the area in square millimeters, square centimeters, or square meters? Why?

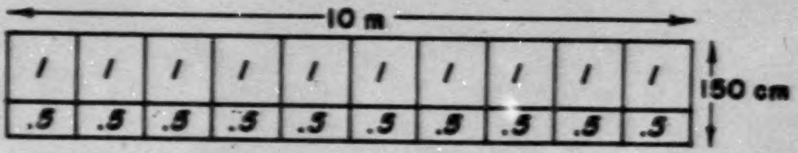
2. Compute the area of the door to your classroom. What unit did you use? Why that one?

3. What is the area of the top of your desk or shop table? What unit did you use? Why?

Lesson 2 Areas of Rectangles

Objective: You should be able to solve simple square-measure problems.

When finding *any area,* all linear measurements must be expressed *in the same unit of measurement.* For example, the length of the hallway below is 10 meters. If the width is given as 150 centimeters (or as 1 meter and 50 centimeters), the units of linear measure are *not* the same.



Before we can find the area of the hallway, the meters must be changed to centimeters or the centimeters to meters.

First we will convert the centimeters to meters (1 meter = 100 centimeters). Meters being larger than centimeters, we divide the number of centimeters by 100.

150 centimeters = 1.5 meters

Now we can go ahead and multiply the length by the width to get the area.

10 meters × 1.5 meters = 15 square meters

As a check, count the square meters in the illustration. You will find 10 squares of 1 square meter each and 10 squares of .5 square meter each, for a total of 15 square meters.

We could have converted the meters to centimeters.

10.00 meters = 1000 centimeters

Then,

1000 cm × 150 cm = 150,000 square centimeters

But this is making an easy problem hard. And for the answer to mean anything in terms of floor tiles to be bought, or capeting, or wooden flooring, you would have to convert the answer into square meters anyway.

Since $1\ \text{cm} = .01\ \text{m}$

Then $1\ \text{cm}^2 = (.01)^2\,\text{m}^2 = .0001\ \text{m}^2$ (one ten-thousandth) m^2

or

$10{,}000\ \text{cm}^2 = 1\text{m}^2$

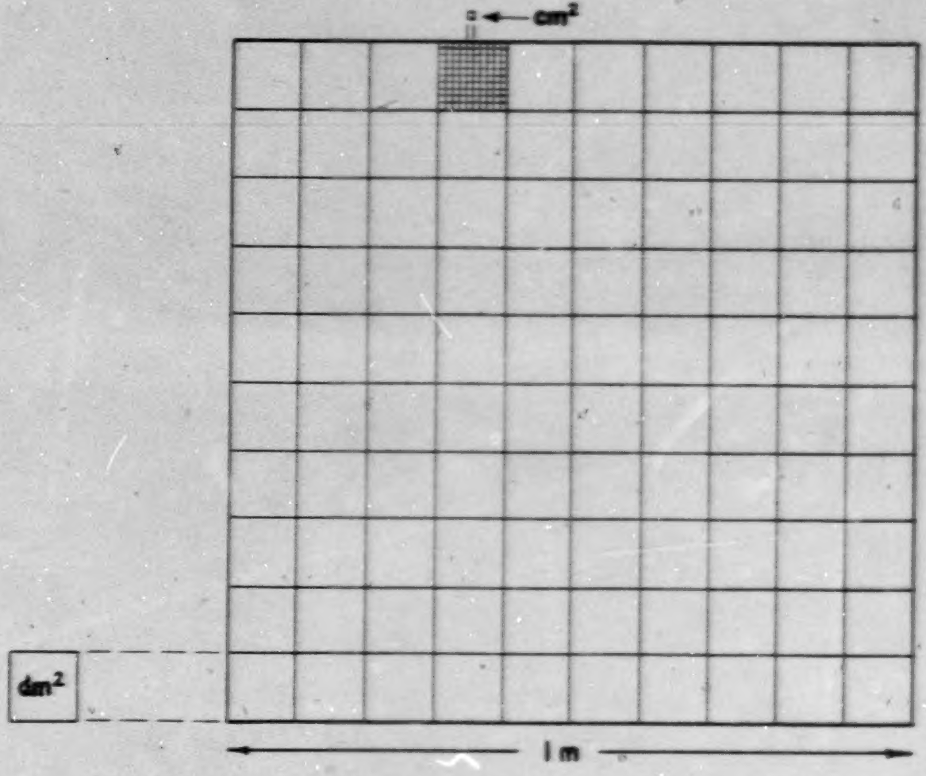
Since we have to convert from a *smaller* to a *larger* measure, we must *divide* the answer by 10,000.

$$150{,}00 \div 10{,}000 = 15{,}0000. = 15\ \text{m}^2$$

Always choose the unit that is easiest for you to work with. Then make sure that you correctly express both measurements in that unit. It may still be necessary in some cases to convert the answer to a different unit.

Does it seem impossible to you that there could be *10,000* square centimeters in a square meter? Perhaps the diagram below will make it more believable.

The large square represents *one square meter*. Each edge has been divided into 10 *decimeters*. You can see that there are 100 square decimeters in the square meter. Now look at the square decimeter that is marked off in *square centimeters*. There are 100 square centimeters in the one square decimeter, and 100 square decimeters in the one square meter. So there are 100 X 100, or 10,000 square centimeters in the square meter.



Below is a table of equivalents for square measure. Notice the abbreviations as well as the names.

Most Common Metric Area Units

Unit	Symbol	Equal to
square kilometer	km^2	1,000,000 m^2
hectare	ha	10,000 m^2
square meter	m^2	Basic square unit
square centimeter	cm^2	.0001 m^2 (1/10000 m^2)

PROBLEMS

1. Find the area, or square measure, of the floor in your classroom. How many square meters of tile are needed to cover the floor? Why would we use square meters instead of square millimeters to measure the floor? Would we use square centimeters? Why or why not? ________

2. Measure and calculate the area of one wall of your classroom or shop. Would you use square meters or square centimeters? Why? ________

3. Measure and calculate the area of a pane of glass in your classroom or shop. Would you use square centimeters or square millimeters? Why? ________

4. Measure and calculate the area of a section of lawn or playground outside your classroom. Would you use square millimeters, square centimeters, or square meters? Why? ________

5. Find the area of a flat-bed truck-body floor that is 6.1 meters by 1.9 meters. ________

6. How many square meters of linoleum are needed to cover a room 4.2 meters by 5 meters? ________

7. How many square meters of floor space will be taken up by a cutting table 120 centimeters wide by 7 meters long? (Caution: Remember that the units must be the same in order to find area.) ________

8. Flagstone for outdoor patios is sold by the square meter. How many square meters must a contractor order for a patio 8.6 meters long and 2.1 meters wide? ________

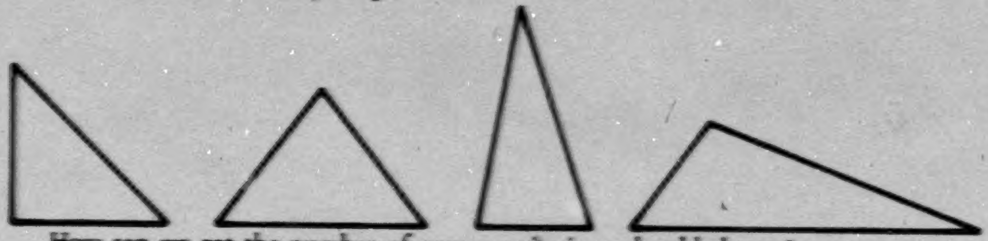
9. A kitchen-cabinet maker measured a counter and found it to be 3 meters long by 52 centimeters wide. He charged for plastic covering by the square meter. How many square meters were there? ________

10. A walkway was to be paved with bricks. It was 12 meters long by 1 meter 10 centimeters wide. What was the area to be paved? ________

Lesson 3 Areas of Traingles

Objective: You should be able to calculate the areas of triangles.

Triangles come in many shapes. Here are a few:



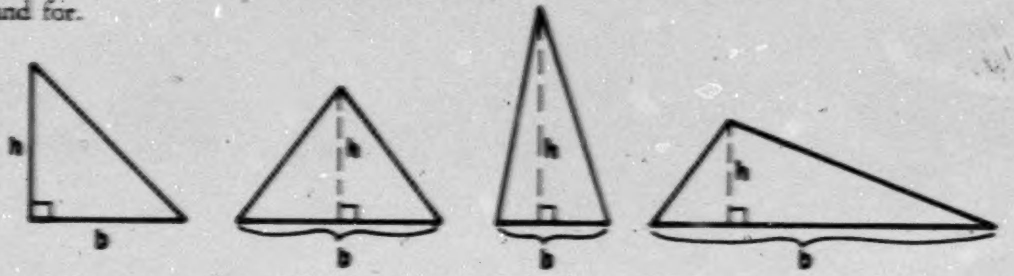
How can we get the number of square units in such odd shapes?

Actually, finding the area of a triangle is not a bit difficult – we don't have to rule it off into squares and count up the bits and pieces. We have a *formula* for finding it.

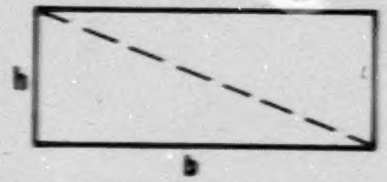
$$\boxed{A = 1/2\ bh}$$

What is b and what is h? The b stands for *base* and the h for *height*. The base can be any side of the triangle – usually the side on which the triangle seems to "stand." Then h is the shortest line from the opposite angle drawn to that base. The shortest line makes a *right angle* (square corner) with that base.

Look at the following triangles and you will understand better what b and h stand for.



In case you forget the formula, this picture should help you remember it.



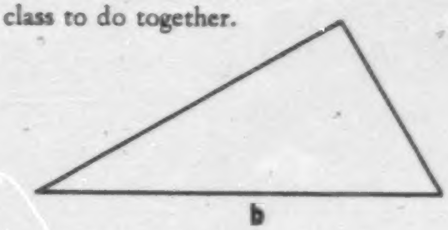
You know that the area of the above *rectangle* is the length times the width – in this case b × h. We have divided the rectangle into two equal triangles with a dotted line. Therefore the area of *one triangle* is equal to *one-half* the area of the rectangle, or

$$A = 1/2\ bh$$

Now measure h and b on the above triangle and find the area.

Did you get the area equal to 5 cm^2? If you did, you were correct.

Here is another problem for the class to do together.

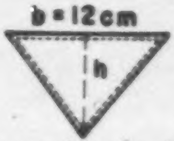


Draw in a dotted line for h. Measure it. Use the formula.

Did you get the area equal to 7.5 cm^2?

PROBLEMS

1. A dress has two triangular pockets that measure 12 cm across and 8 cm in height. What is the area of one pocket? What is the area of two pockets?



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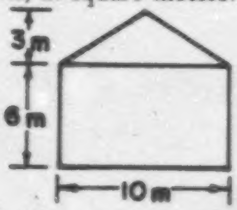
2. You are putting aluminum siding on a house. What is the area of the triangular area shown, in square meters? What is the area of the entire side of the house?

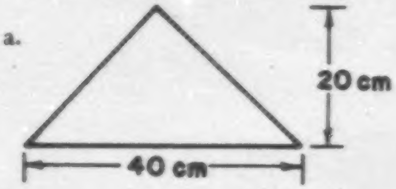


____

____

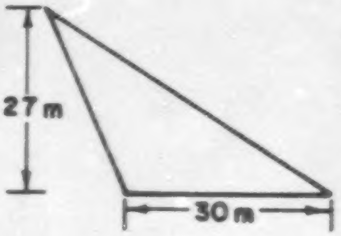
3. Find the area of the following triangles

a.



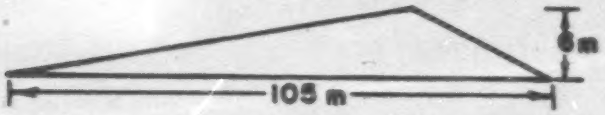
____

b.



____

4. The owner of a large business wanted to make a lawn out of a triangular section in front of his store. The landscaper measured the area to find out how much grass seed was needed. How many square meters will be seeded?



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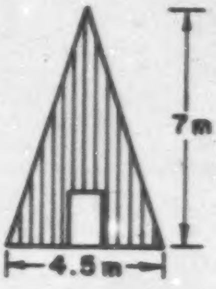
5. A man built an A-frame vacation home. How much board-and-batten lumber (in m^2) was needed for this end? (Disregard door.)



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UNIT IV – AREA MEASUREMENT

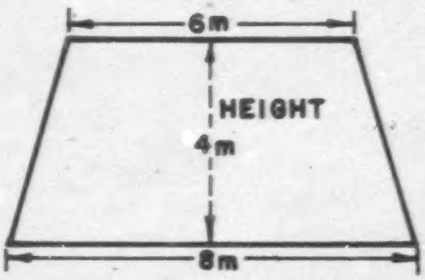
Lesson 4 **Areas of Trapezoids**

Objective: You should be able to calculate the area, or square measure, of a trapezoid.

A trapezoid is the name of a 4-sided figure that has two sides parallel to each other and two sides that are not parallel to each other. The two parallel sides are called the *bases* of the trapezoid. The shortest distance between the bases is called the *height*. As in a triangle, the height makes a right angle (square corner) with the bases.

The area of a trapezoid equals its height multiplied by one-half the sum of its two bases.

$$\boxed{A = h \times \tfrac{1}{2}\,(\text{Base \#1} + \text{Base \#2})}$$



Now this is not as hard to remember as it looks. The two bases are different lengths. If you were to get their *average* length, you would add the lengths together and divide by 2. In effect, that is what the formula does. It multiplies the height by the average length of the two bases.

Let us find the area of the trapezoid above.

$$\text{Area} = h \times \frac{B_1 + B_2}{2}$$

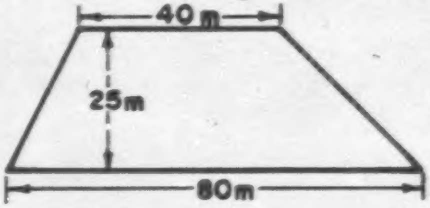
$$\text{Area} = 4 \times \frac{8 + 6}{2}$$

$$= 4 \times 7$$

$$= 28 \text{ m}^2$$

PROBLEMS

1. Find the area of trapezoid below in m^2.

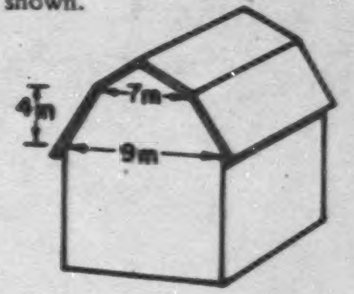


______

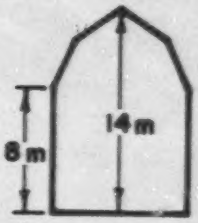
2. Find the area of the above trapezoid if the height is changed to 25 *centimeters* and the bases remain the same.

______

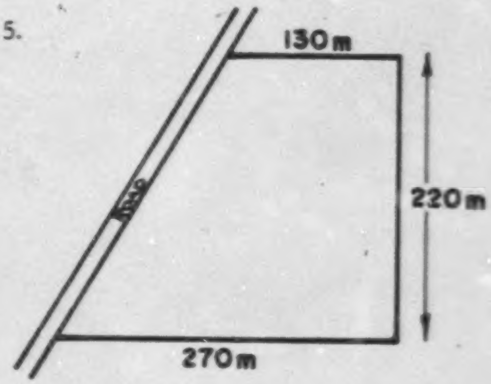
3. Calculate the area of the trapezoid in the end of this barn, using the measurements shown.



4. If the above barn measures 8 m in height to the roof overhang, and 14 m in overall height, to the peak of the roof, calculate the area of one end. (Hint: What three parts is the end made up of?)



5.



How many square meters in this farmer's field?

How many hectares in the field?

6. See if you can solve the above problem by dividing the field into a triangle and a rectangle and adding the two areas. You should get the same answer as for problem 5 above.

UNIT IV – AREA MEASUREMENT

Lesson 5 **Areas of Circles**

Objective: You should be able to calculate the area of circles.

Finding the area of a circle is very useful in many trades. The machinist or mechanic may need the area of a piston. The landscape gardener may need to find the area of a circular bed in order to figure out how many plants will be needed. The mason may need to construct a circular concrete surface, and must be able to compute the area to figure the amount of concrete needed. A heating contractor may need to find the cross-section area of a circular duct. And so on.

The area of a circle can be found by a formula. The area is equal to pi (π) times the radius squared (r^2), or

$$\boxed{A = \pi r^2}$$

The radius, you remember, is the distance to the center, and the value of π is, as always, 3.14, or 3.1416 if more accuracy is needed.

Example:

The circular end of a tractor gas tank measures 40 centimeters across. What is the area of the end of the gas tank?

$$A = \pi r^2$$

If the diameter of the gas tank equals 40 centimeters, then the *radius* equals 1/2 the diameter: $1/2 \times 40 = 20$.

So,

$$A = 3.14\ (20)^2$$

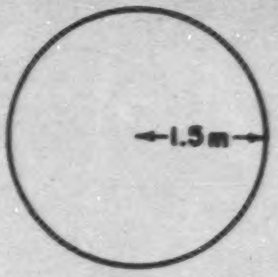
$$A = 3.14 \times 400$$

$$A = 1{,}256\ \text{cm}^2$$

Remember two things in finding areas of circles:

1. You cannot use the diameter. You must get the *radius* for this formula.
2. If two units are not the same, one measurement must be converted to the other unit first. You should choose the unit that will give you a sensible answer.

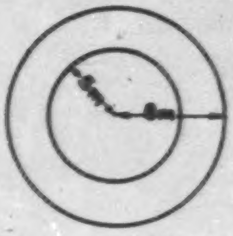
PROBLEMS



1. A mason was told to lay out a circular base for a water fountain. The distance from the center to the edge was to be 1.5 meters. What was the area of the circular base?

____

2. A circular walk around a display in a park was laid out using an 8-meter radius for the outer edge and a 5-meter radius for the inner edge. Calculate the area of the inner circle. Calculate the area of the outer circle. Now subtract the area of the inner circle from the area of the outer circle. The difference is the area of the sidewalk.



Inner area ________

Outer area ________

Area of walk ________

3. What is the area of the largest circle that can be cut from a piece of fabric 90 centimeters square? What is the area of the fabric that is not in the circle? (Hint: Draw a sketch).

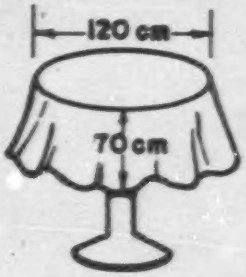
____

____

4. What is the area of a wheel with a 34-centimeter diameter?

____

5. What is the area of a circular tablecloth needed to cover the table shown here if the cloth is to hang down 70 centimeters?



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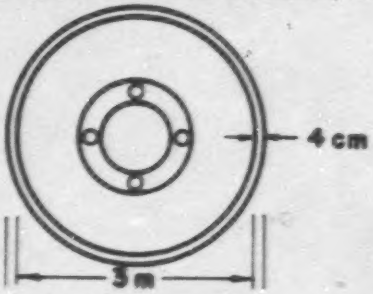
6. The diameter of a tank is 3 meters. How many square meters of metal are needed for a tank cover that is 4 cm wider than the tank all the way around? (Hint: Express the new diameter in terms of meters, using a decimal. Then find the radius.)



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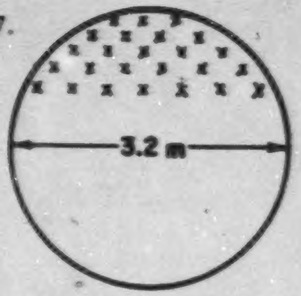
7.



A landscape gardener laid out a circular bed for begonias that was 3.2 meters across. What was the area of the bed?

____

If the gardener figured on 16 plants for each square meter, how many plants would he need?

____

8. What is the area of a piston whose diameter is 9.04 centimeters? (Use the more exact figure for π.)

____

9. For calculating the number and sizes of outlets needed in the various rooms of a house, a heating contractor needed to know the areas of circular ducts. Find the area of (a) a 14-centimeter (diameter) duct; (b) a 20-centimeter duct.

(a)__________

(b)__________

10. This clown doll requires 98 circles 14 cm in diameter. What is the total area of the circles? If 2 meters of 90 cm wide material is needed, how many square centimeters of material are wasted?

Total area __________

Waste __________

UNIT IV – AREA MEASUREMENT

Lesson 6 More Applied Problems in Area

Objective: You should be able to select appropriate measurement units and calculate area for applied problems.

1. Write in the most appropriate unit for computing areas of the following objects. Write the symbol of the linear unit and the symbol of the square unit.

		Symbol	
	Unit	**Linear**	**Square**
a. Textbook	________	________	________
b. Desk top	________	________	________
c. House exterior – for painting	________	________	________
d. Floor	________	________	________
e. House lot	________	________	________
f. Farm	________	________	________
g. Township	________	________	________
h. Copper wire (cross section)	________	________	________

2. How many square meters of artificial turf are needed for a field 90 m X 50 m?

____

3. A house lot is 42.6 m X 51.5 m. What is the area of the house lot in hectares?

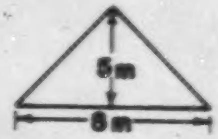
____

4. You are painting a triangular area that is 5 meters by 8 meters. What is the area in square meters? If one liter of paint will cover about 10 square meters, how many liters of paint are needed for one coat? for two coats?

____

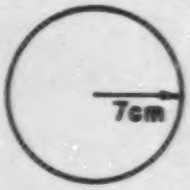
____

____

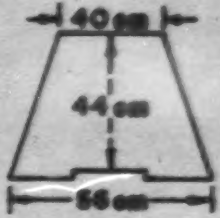


5. Calculate the area of the circle below.

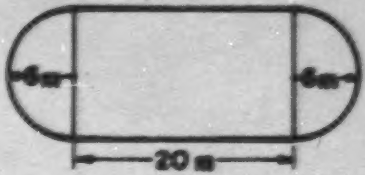
____



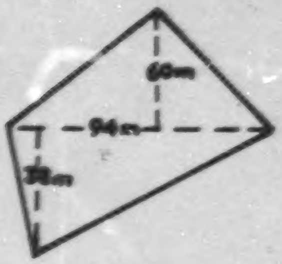
6. Calculate the approximate area of this concrete support for a park bench.



7. Think carefully. See if you can calculate the area within the race-track shown below.



8. A farmer knows the three measurements shown below on a sketch of one of his fields. Find the area in hectares of this field. (Hint: Can you find the bases and heights of two triangles?)

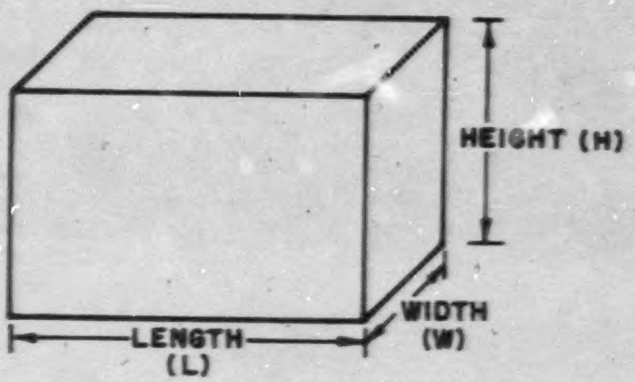


UNIT V – VOLUME

Lesson 1 — **Volume of Rectangular Solids**

Objective: You should be able to calculate the volume of rectangular solid objects.

Volume is the amount of space occupied by an object. All objects have length, width, and height: these are called its *dimensions.*



The cubic meter (m^3) is used to measure the volume of bins, boxes, and other large containers, and also of solids like sand, gravel, and cement. A cubic meter is 1 meter long by 1 meter wide by 1 meter high.

If you are pouring concrete for a wall that is 4 meters long by .25 meters wide by 2 meters high, how many cubic meters of concrete will you have to order?

To solve this problem, we multiply all three dimensions.

$$\boxed{\text{Volume} = L \times W \times H}$$

V = 4 meters × .25 meters × 2 meters = 2 cubic meters (m^3)

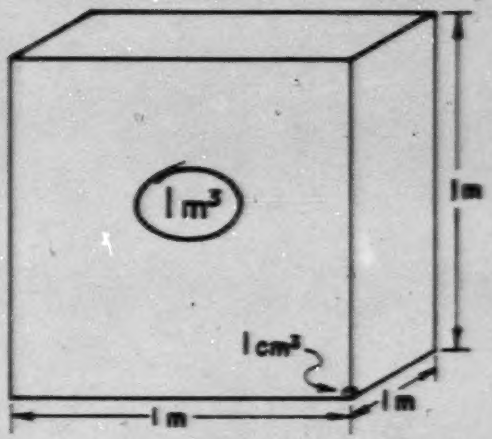
How many cubic meters of concrete are in the following walls?

	Length	Width	Height	Cubic Meters
(a.)	20 m	.4 m	3 m	____
(b.)	40 m	.8 m	6 m	____
(c.)	35 m	20 cm	2 m	____

In order to determine the proper size of air conditioner or heater needed to cool or heat a room, you have to first determine the volume of space in that room. Here are some problems for you to try.

	Length	Width	Height	Volume
(d.)	4 m	3 m	2.5 m	______
(e.)	3.5 m	3.1 m	2.2 m	______
(f.)	5 m	3.5 m	3 m	______

It is possible to measure the volume of solids in cubic kilometers, cubic hectometers, cubic decameters, cubic decimeters, cubic centimeters, and cubic millimeters. But the most common metric measure of the volume of large solids is the *cubic meter*, while small solids are usually measured in *cubic centimeters* (cm^3).



You know that 1 meter equals 100 centimeters. If you can picture a cubic meter, you can see that its length would be 100 centimeters, its width would be 100 centimeters, and its height would be 100 centimeters. How many cubic centimeters would there be in that cubic meter?

$$V = L \times W \times H$$
$$V = 100 \times 100 \times 100$$
$$= 1{,}000{,}000 \text{ cubic centimeters}$$

You can see that a cubic meter is very large.

In finding the volume of anything, you must be sure that all dimensions are expressed *in the same unit* before you multiply, or your answer will be all wrong.

PROBLEMS

1. A dump truck body is 4 meters long, 2.7 meters wide, and 1.6 meters high. How much sand will it hold?

____

2. A heating contractor had to decide the proper size furnace for a ranch-style house 10.2 meters long by 7.6 meters wide by 3 meters in height (to the ceiling). What was the volume of the living space in that house?

____

3. A box of detergent is 16 centimeters by 5 centimeters by 20 centimeters. How many cubic centimeters of detergent will it hold?

____

4. Find the volume of a shallow box 1 meter long by .7 meter wide by 22 *centimeters* high.

____

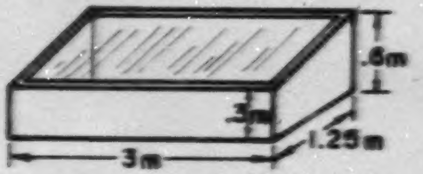
5. What is the cubic content of a storage bin for coal that is 3.6 meters square and 1.8 meters high?

____

6. A concrete walk was to be made 1.2 meters wide, 12 meters long, and 20 centimeters deep. How many cubic meters of concrete would be needed for it?

____

7. This is a sketch of a hot bed for growing vegetable and flower seedlings. The ends are trapezoids with bases of .3 and .6 meters and a height of 1.25 meters. To get the volume, first find the area of an end and multiply this by the length of the frame. Find the volume.



____

8. Go back to problem 6 on page 56. If the concrete support is 12 centimeters thick, how many cubic centimeters are there in the support? See if you can express this amount as the decimal part of a cubic meter.

________ cm^3

________ m^3

9. A farmer needed a pit to store potatoes. He wanted it to be able to hold about 4 cubic meters. If the pit was to be 1 meter deep and 1.8 meters wide, how long would it have to be? Suggestion: draw a sketch.

____

10. A shipping carton was needed that was to hold about .5 cubic meter. If it was to be 1.2 meters long and .7 meter wide, how high would it have to be?

____

UNIT V – VOLUME

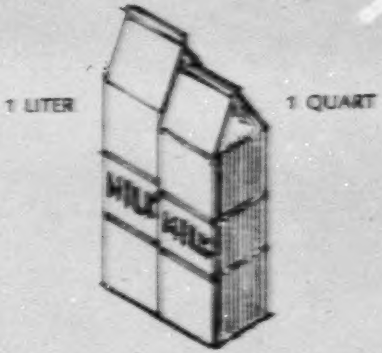
Lesson 2 Volume of Liquids

Objective: You should be able to state the basic unit of liquid volume and how it compares with other metric units and with English units.

Right now we buy milk by the quart and gasoline by the gallon. Cooks measure with cups, tablespoons, and teaspoons. But nurses measure with milliliters. How will the metric system change this?

With the metric system, we will buy both our milk and our gasoline by the liter. And cooks will use milliliters just as the nurses do now.

Let's take another look at the liter, because it is the most common metric measure of liquid volume. A liter is just a little larger than a quart. (It is actually equal to 1.06 quart.)



Now let's take a look at the liquid measures used in cooking.

1 cup = 237 milliliters (ml)
1 teaspoon = 5 milliliters
1 tablespoon = 15 milliliters

Recipes that now call for a cup will generally change to 250 milliliters, because that is accurate enough for most cooking. The 5 milliliter and 15 milliliter measures will replace the teaspoon and the tablespoon.

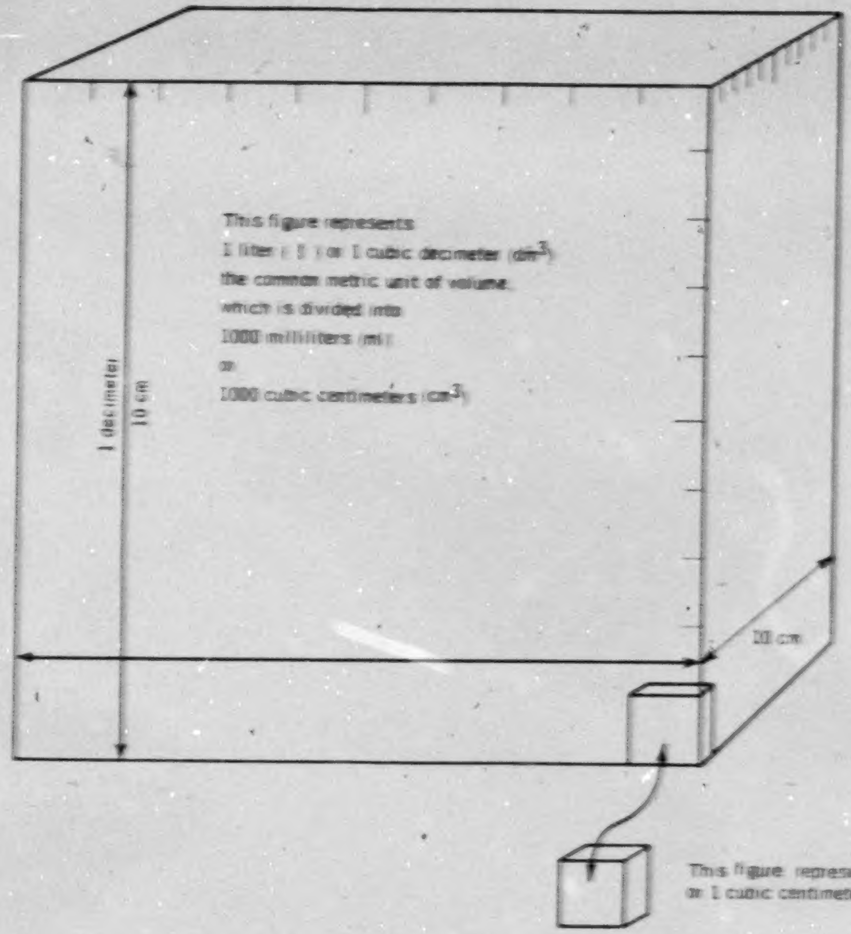
The medical profession has already changed to some metric measurements. For example, medicines are measured in milliliters. So, the changeover to metrics will be easy for nurses.

One thing that makes metrics easy to work with in liquid measure is the fact that 1 milliliter (liquid measure) is exactly equal to 1 cubic centimeter (solid measure), and 1 liter (liquid measure) is exactly equal to one cubic decimeter (solid measure). See how different this is from our present system.

Suppose you know that a waxed carton contains 48 cubic inches. Would you know how many cups or quarts it holds? Certainly not, at least not without a great deal of figuring. But if you knew that a carton contained 725 cubic centimeters, you would know instantly that it held 725 milliliters, or .725 of a liter.

Here is a table of metric units of volume, solid and liquid.

Solid Measure	**Liquid Measure**	
1 cubic meter (m^3)	= 1 kiloliter (kl)	= 1000 l
1 cubic decimeter (dm^3)	= 1 liter (l)	= BASE UNIT
1 cubic centimeter (cm^3)	= 1 milliliter (ml)	= .001 l (1/1000 l)

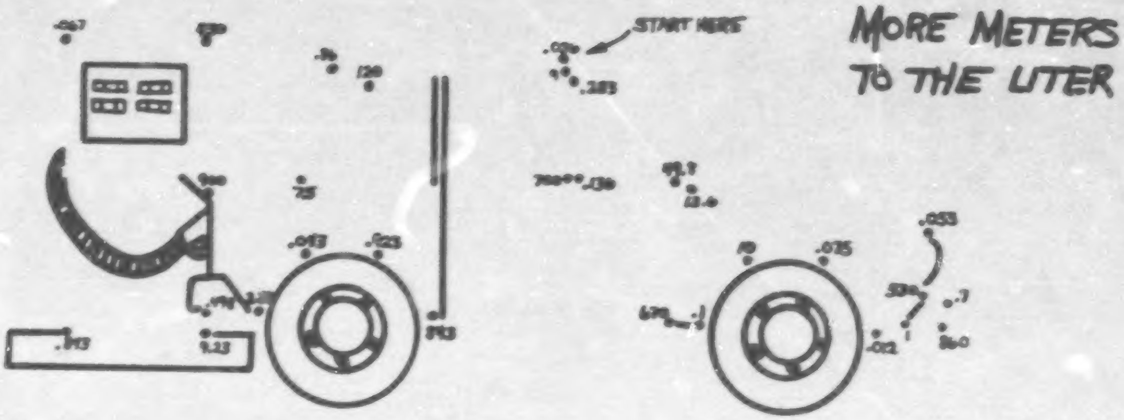

This figure represents
1 liter (l) or 1 cubic decimeter (dm^3)
the common metric unit of volume,
which is divided into
1000 milliliters (ml)
or
1000 cubic centimeters (cm^3)
1 decimeter
10 cm
10 cm

This figure represents 1 milliliter (ml) or 1 cubic centimeter (cm^3)

PROBLEMS

1. Which is larger, a liter or a quart? ________
2. If gasoline sells for $1.00 a gallon or 25¢ a liter, which is more gas for the money? ________
3. Is 250 milliliters larger or smaller than a cup? ________
4. Approximately how many cups of milk are there in a liter? ________
5. How many milliliters are there in a teaspoon? ________
6. How many cubic centimeters are there in a teaspoon? ________
7. How many liters are there in a teaspoon? ________
8. If a certain fire hose can discharge 18,000 cubic centimeters of water per second, how many liters can it discharge per second? ________

9. Connect the answers in order and complete the picture.


START HERE
MORE METERS TO THE LITER

1. 86 l = ____ kl
2. 860 ml = ____ l
3. .9 kl = ____ l
4. .43 kl = ____ l
5. 67 ml = ____ l
6. 843 ml = ____ l
7. 9.23 cm^3 = ____ ml
8. 498 l = ____ kl
9. 2.83 l = ____ dm^3
10. 43 l = ____ kl
11. 923 l = ____ kl
12. .843 l = ____ ml
13. 670 ml = ____ cm^3
14. 4.98 cl = ____ ml
15. 283 ml = ____ l
16. 136000 ml = ____ kl
17. 700 dm^3 = ____ l
18. .9 cl = ____ ml
19. 120 cm^3 = ____ ml
20. 7.5 l = ____ dm^3
21. .0136 kl = ____ l
22. 53 ml = ____ l
23. 5.3 l = ____ cl
24. .0007 l = ____ ml
25. .86 l = ____ ml
26. .1 cl = ____ ml
27. .012 m^3 = ____ kl
28. 75 l = ____ kl
29. 10 cm^3 = ____ ml
30. 100 ml = ____ l

10. MIX AND MATCH PUZZLE II

(Volume Measure)

On the next page you will see the sheet you are going to work on.

Cut the squares on this page apart. You are going to arrange these squares on the next page so that every measurement *has the same value* as the measurement adjacent (right next) to it. See the example below. When you are sure your solution to the puzzle is correct, paste or tape your squares down.

570 kl .04 ml 100l 23 cm^3	23 m^3 40 ml .01 kl 570 dl	.057 kl 400 l .4 l 23 ml	.23 l 4 l .01 l 57 kl
57 cl 10 dl 40 cm^3 23 l	23 cl .1 kl 40 kl 230 cl	2.3 cl 10 l 4 kl 570 l	57 ml 400 ml .01 ml 5.7 l
23 ml .4 ml 10 cl 570 ml	57 l 4 ml 1 ml 2.3 dl	.57 l 40 m^3 4 ml 57 l	57 dl 4000 l 400 kl 230 ml
.023 kl .01 ml 4 cm^3 .057 ml	2300 ml 1 dl 400 dm^3 23 kl	570 dm^3 .1 cl 4 dm^3 .023 ml	23 kl 4 cm^3 .1 ml 5.7 cl

.01 kl	10 l 4 kl 570 l	4000 l
	570 dm^3	

SOLUTION TO MIX AND MATCH PUZZLE II

570 kl .04 ml 100 l $23\ cm^3$			

Lesson 3 — Volume of Cylinders

Objective: You should be able to calculate the volume of cylinders.

Today cylinders are used everywhere. Grain is stored in cylinders called silos. Milk, gasoline, and various chemicals are delivered in large cyclinders called tank trucks. Many round columns of concrete are used in the construction industry. There are also many other uses of cylinders that you might want to add to the list. Since you may be using cylinders, your job may require that you know how to find the volume of a cylinder.

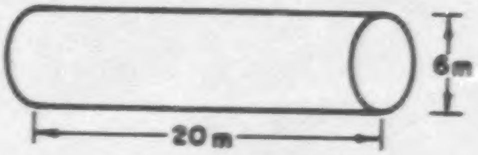
To calculate the volume of a cylinder, use this formula:

$$\boxed{V = \pi r^2 h}$$

where
V = volume
π = 3.1416 or 3.14
r = radius of round end
h = height (distance between the round ends)

Note that this formula is actually the area of an end times the height (or length) of the cylinder.

Let's try the formula with this cylinder.



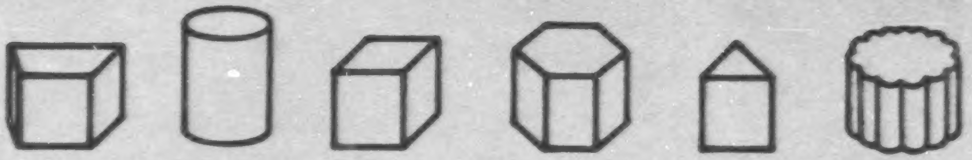
r = ½ diameter, or 3 m in this problem.
h = 20 m

So,

$V = 3.14 \times 3^2 \times 20$
$V = 3.14 \times 9 \times 20$
V = 565.2 cubic meters

For Class Discussion

Up to this point we have found the volume of rectangular solids and cylinders. Twice (page 59, problems 7 and 8) we found the volume of solids where the ends were trapezoids. The class should work up a general rule for finding the volume of any of the objects shown on the next page.



PROBLEMS

Find the volume of the following cylinders:

	Radius	Height	Volume
1.	2 m	10 m	_____
2.	3.2 m	13 m	_____
3.	1 m	8 m	_____

	Diameter	Height	Volume
4.	1.8 m	1.8 m	_____
5.	10 cm	21 cm	_____
6.	46 cm	1.3 m	_____

7. A gas tank on a tractor-trailer measured 60 centimeters across the ends and was 1.24 meters long. Find its volume in (a) cubic meters, (b) liters.

(a) __________

(b) __________

8. A milk-truck tank had oval ends which had an area of 4.4 square meters. The tank was 7 meters long. How many liters of milk could the tank hold?

____

9. A glass tube measured 4 millimeter across (inside diameter) and was 40 centimeters long. How many milliliters could it hold?

____

10. A silo on a farm was 4.2 meters across and 13 meters tall. How much silage could it hold?

____

UNIT V – VOLUME

Lesson 4 — Review Problems in Volume

Objective: You should be able to calculate volume for selected problems, giving the answers in appropriate units.

1. How many cubic centimeters are there in a liter?
2. Which is larger – a liter or a cubic decimeter?
3. How many liters are there in a cubic meter?
4. How many cubic centimeters are in a rectangular container that is 10 cm by 15 cm by 20 cm? How many milliliters are in this container?
5. A tank contains 5,000 liters of water. How many cubic meters of water are in the tank?
6. Calculate the volume in cubic meters of a propane gas tank that is 16 meters long with a diameter of 6 meters. What is the volume in liters?
7. A milk carton measures 7 cm by 7 cm by 10.3 cm. How much milk will it hold when completely full?
8. Each concrete pillar for a raised road was to have a diameter of 80 centimeters and be 8 meters tall. How much concrete was needed for 100 of them?
9. A cylindrical collector for liquids in a chemical plant was 2.2 meters across and 2.5 meters high. How much liquid could it hold?
10. A cooking pot measured 24 cm across and was 21 cm high. How much liquid could it hold?

UNIT VI – MASS or WEIGHT

Lesson 1 **Units of Mass or Weight**

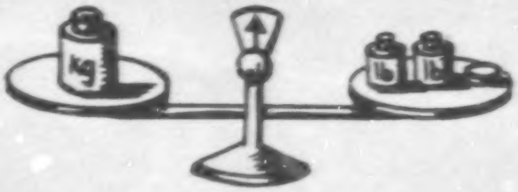
Objective: You should be able to solve simple weight problems, giving your answer in appropriate units.

How much do you weigh?

What is your mass?

The words "mass" and "weight" have slightly different meanings to the scientist, but for our purposes we will consider them to be the same thing. So if you see a metric conversion table labeled "Units of Mass," you will know that it means weight.

Just as our present basic unit of weight is the pound, the basic metric unit is the *kilogram*. Sometimes it is called "kilo" for short. Unlike the quart and the liter, however, there is a big difference between the pound and the kilogram. In fact, the kilogram weighs over twice as much as the pound.



The small metric unit of weight generally used is the *gram*. The very large unit is the *metric ton*. Here is a table showing the relationship among these three units.

1 metric ton (t) = 1000 kg
1 kilogram (kg) = BASIC UNIT
1 gram (g) = .001 kg (1/1000 kg)

To help you think in metric terms:

A paper clip weighs about 1 gram.
A nickel weighs about 5 grams.
A quart carton of milk weighs about 1 kilogram.
And a VW Beetle, with two people in it, weighs about 1 ton.

We saw in Unit V that there was a direct relationship between cubic measure and liquid measure. In metric measure there is also a direct relationship between liquid measure and the weight of water.

1 liter of water (at 4°C) weighs 1 kilogram.

In ordinary use we just say that a liter of water or any liquid that is almost all water weighs 1 kilogram. From this it follows that

1 milliliter (1 cm^3) of water weighs 1 gram.

For Class Discussion

1. What are the most appropriate metric units for weighing the following:

   a. Loaf of bread
   b. Cup of flour
   c. Fertilizer for your lawn
   d. Medicine
   e. Truckload of steel
   f. Bag of sugar
   g. Freight-car load of sugar
   h. Automobile
   i. The vitamin content of a food (Hint: The unit equals .001 gram)
   j. Gold or silver

2. Based on the fact that 1 kg = 2.2 pounds, see if you can figure out the relationship between 1 metric ton and one English ton.

3. Workers in the food trades may find nutritional values of foods expressed in terms of 100-gram portions of those foods. If there are about 28 grams in one ounce, figure out what part of an ounce one gram is equal to. Then figure out how many ounces 100 grams is equal to.

1 gram = _____ ounce

100 grams = _____ ounces

PROBLEMS

1. (a) Which is heavier, a kilogram or a pound? __________

   (b) If you have 10 pounds of flour, will you have more or fewer than 10 kilograms? __________

   (c) To change from pounds to kilograms, you would (divide, multiply) by __________

   (d) To change from kilograms to pounds, you would (divide, multiply) by __________

2. (a) What is the metric weight of 3 l of water? ________

   (b) What is the metric weight of 3 ml of water? ________

   (c) What is the metric weight of 3 cm^3 of water? ________

In the following problems, *give each answer in the most appropriate unit.*

3. A recipe called for 120-gram portions of boneless beef per serving. How much beef would be needed to serve 10 people? ________

4. How much would be needed to serve 50 people? ________

5. A printing shop ordered 1200 cartons of paper. If each carton weighed 30 kilograms, what was the total weight of the order? ________

6. On a package of English muffins was the following chart:

   Serving Size 60 Grams
   (approx. 1 Muffin)

Servings Per Package	**12**
Calories	**150**
Protein	**5 Grams**
Carbohydrates	**28 Grams**
Fat	**2 Grams**

   That part of a food that is not protein nor carbohydrate nor fat is essentially water (aside from very small amounts of minerals and vitamins). Can you figure out how much water there is in each English muffin? ________

7. In a foundry, the weight of a casting is 340 kg, the weight of the sand mold is 585 kg, and the weight of the containing flask is 224 kg. What is the total weight of this unit? ________

8. A small bridge had a sign on it: "WEIGHT LIMIT 5 METRIC TONS." A contractor's truck approached the bridge. The driver knew that his truck weighed 2300 kilograms and his load weighed about 3200 kilos. Was it safe for the truck to use this bridge? ________

9. According to a nutrition chart, Greg needed 1.2 grams of calcium each day in his diet to grow and maintain good health. His food intake for one day included:

   3 glasses (750 ml) of milk @ 300 mg of calcium per glass
   30 grams of American cheese for 210 mg of calcium
   1 egg for 25 mg of calcium
   ½ cup baked beans for 70 mg of calcium
   Other food for approximately 100 mg of calcium

   How much was he over or under his calcium requirements for that day? ____________

10. Denise knew that her body needed about 18 mg of iron each day. According to her chart, 100 grams of chicken livers would give her 8 mg of iron, and a 100-gram portion of spinach would give her 2.5 mg. If she had the chicken livers and the spinach, how much iron would she still have to get that day? ____________

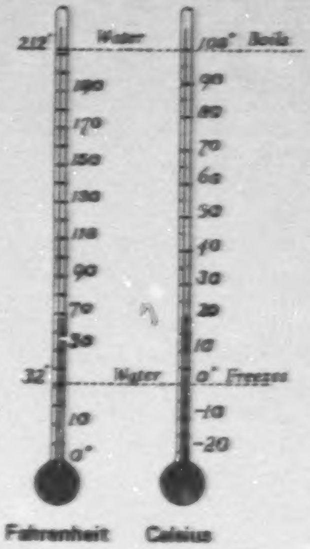
UNIT VII – TEMPERATURE MEASUREMENT

Lesson 1 — The Celsius Scale

Objective: You should be able to select common temperature measurements on the Celsius scale.

Do you think you'd be comfortable sitting in a room watching TV if the room thermometer read 20 degrees? You would if the thermometer had a Celsius scale, and you were reading 20 degrees *Celsius!*

Here is a sketch of two thermometers reading the same temperature. The old one – Fahrenheit – reads 68° at the same time that the metric one – Celsius – reads 20°. (The Celsius scale used to be called centigrade, but the name was changed to honor its inventor, Anders Celsius, a Swedish scientist who died about 250 years ago.)



Although scientists in America have been using the Celsius scale for many years, the rest of us have not. We will have to learn to think of temperatures differently. To help us do that, let's take a closer look at the two thermometers shown here.

The Celsius scale is based entirely on the boiling and freezing points of water. The scale is drawn so that the point where water freezes is marked 0° and the point where water boils is marked 100°. The distance between these two points on the scale is divided into 100 equal spaces. Then the same size division is continued above 100° and below 0°.

On the other hand, Gabriel Fahrenheit, a German scientist who lived at about the same time as Celsius, set the zero on his scale at the temperature produced by mixing equal weights of snow and salt. On the Fahrenheit scale, the freezing point of water is at 32°, and the boiling point at 212°. The distance between them has 180 equal divisions, which are also continued above and below.

So you see that there are 100 degrees between the freezing and boiling points of water on the Celsius scale, and 180 degrees on the Fahrenheit scale. This means that each degree Celsius will cover almost twice the temperature range of each degree Fahrenheit. The formulas for converting from one scale to the other are:

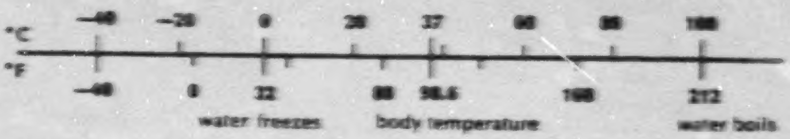
$$F = \frac{9}{5}C + 32$$

$$C = \frac{5}{9}(F - 32)$$

As a practical matter, you won't have time to convert from Fahrenheit to Celsius each time you use a thermometer, so you will need to become as familiar with the Celsius scale as you are with the Fahrenheit scale now.

For examples of the most common temperatures, see the chart below.

TEMPERATURE



PROBLEMS

1. What is the freezing point of water on the Fahrenheit scale? ________
2. What is the freezing point of water on the Celsius scale? ________
3. What is the boiling point of water on the Celsius scale? ________
4. What is the boiling point of water on the Fahrenheit scale? ________
5. Which covers a greater range of temperature, one degree on the Celsius scale or one degree on the Fahrenheit scale? ________
6. A comfortable room temperature on the Fahrenheit scale is considered to be ________
7. The same temperature on the Celsius scale is ________
8. What is body temperature on the Celsius scale? ________
9. What is body temperature on the Fahrenheit scale? ________

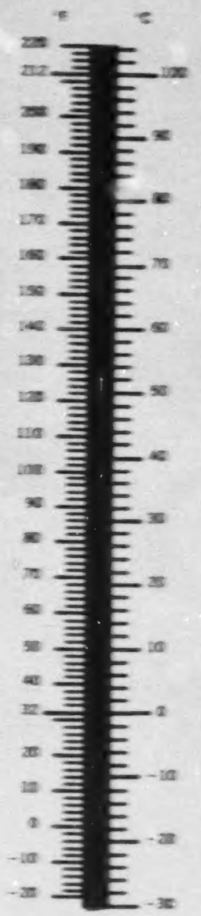
Lesson 2 **Using Common Celsius Measurements**

Objective: You should become familiar with additional common temperature measurements on the Celsius scale.

You have already learned the Celsius readings of boiling water, freezing water, room temperature, and body temperature. It didn't take long. Now you will learn more Celsius readings for common temperature measurements.

You will be using the temperature-conversion chart on the right to determine the Celsius readings for some common temperatures. It is easy to use. Find the Fahrenheit temperature on the left-hand scale; then read the Celsius temperature directly across, on the right-hand scale.

TEMPERATURE CONVERSION



PROBLEMS

1. Your doctor tells you that you have a fever of 102°F. What is your approximate temperature on the Celsius scale? ________

2. The weather report said that the temperature would drop to about 10°F. What would this be on the Celsius thermometer? ________

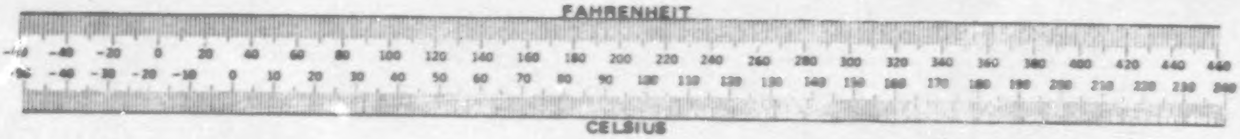
3. It is a very hot day with the temperature in the high nineties. What is the approximate reading on the Celsius scale? ________

4. Which is warmer – 25°F or 25°C? ________

5. When roasting well-done beef, the internal temperature should be about 170°F. What is the approximate Celsius reading? ________

6. If your freezer is kept at 0°F, what would the approximate temperature be on the Celsius scale? ________

The temperature-conversion scale on the next page has a wider range of temperatures than the scale above. Use it for the rest of the problems.


FAHRENHEIT
-40
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
CELSIUS

7. A certain temperature-indicating crayon used in heat-treating steel melts at 319°F. What temperature is this on the Celsius scale? ________

8. The tempering temperature of twist drills for hard service is 450°F. What is the tempering temperature on the Celsius scale? ________

9. Quenching solutions used in hardening steel may be of water, brine, or oil. Water or brine should be at about 60°F for quenching, while oil cools best at temperatures of about 100°F. to 140°F. Find the corresponding Celsius temperatures.

Water or brine: ________

Oil: ________ to ________

10. The following are cooking temperatures of foods on the Fahrenheit scale. Find the temperatures on the Celsius scale.

Baking: Oven Temperatures	°F	°C
Very slow	250 to 275	___ to ___
Slow	300 to 325	___ to ___
Moderate	350 to 375	___ to ___
Hot	400 to 475	___ to ___

UNIT VIII – METRIC THREAD

Lesson 1 **Unified National and Metric Thread Systems**

Objective: You should be familiar with the unified national and metric thread systems.

You may have heard the expression, "A chain is no stronger than its weakest link." We might invent a similar expression, "A huge machine is no stronger than its tiniest screw or bolt,"

Why do we say that?

Suppose a tiny screw or bolt breaks off or is lost in cleaning or repairing a machine. Unless it can be replaced with an *identical* one, it may be impossible to get that machine to work properly.

That is why thread *standards* for screws and bolts have been developed through the years. So long as the same standards are followed in manufacturing, we know that a screw or bolt can always be replaced by an identical one.

Standardization of machine parts is also important. Interchangeability of machine parts manufactured in different countries makes it easier to replace worn or broken parts.

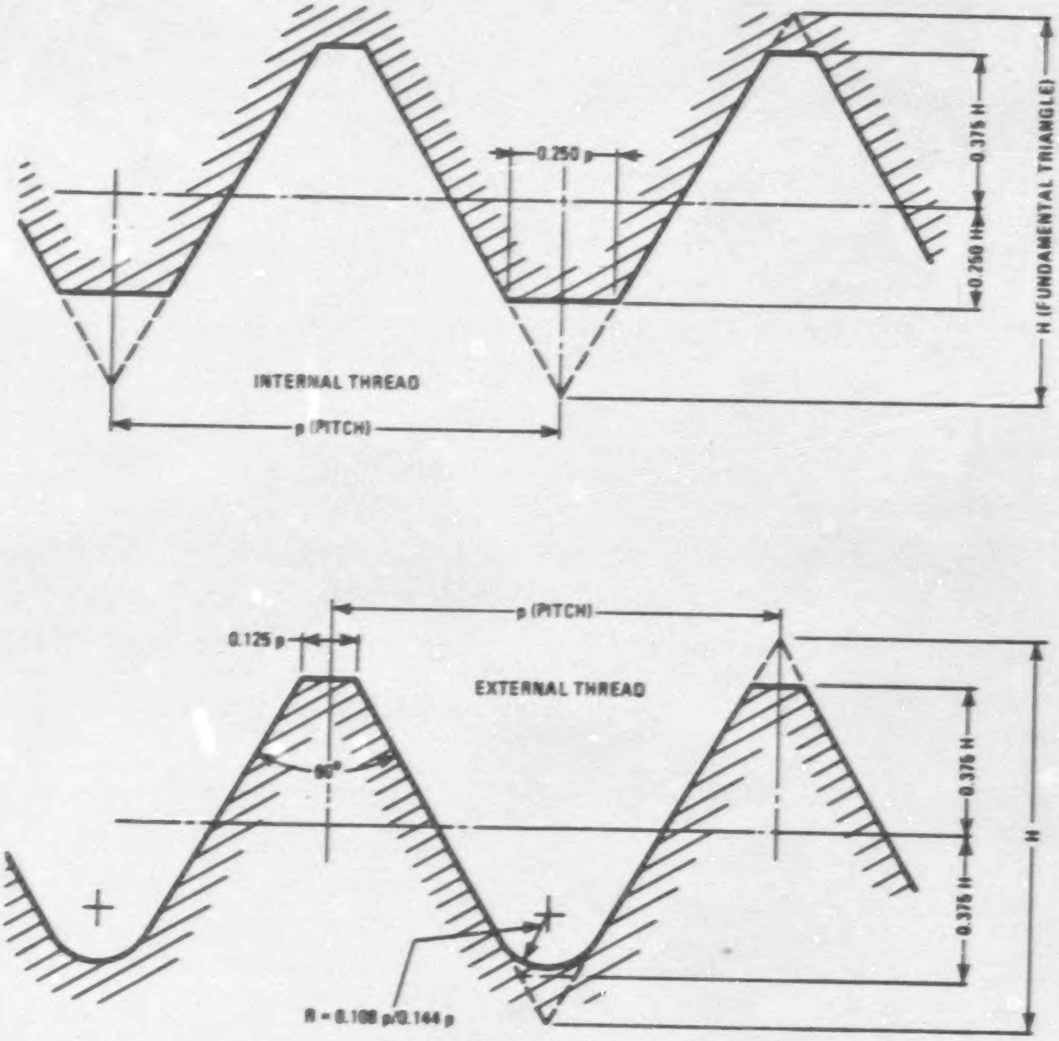
In 1948, the United States, Great Britain, and Canada adopted the Unified National Thread System. The system provided for a coarse-thread series (UNC) for the most common bolts, screws, and nuts for general engineering applications, a fine-thread series (UNF) for thread applications requiring greater tensile strength, and an extra-fine-thread series (UNEF) for specialized uses where the UNC and UNF threads were not acceptable. The Unified National Thread System is still the most common thread system used in the United States.

Times change, and so do thread systems. Today the countries that import our machines use the metric system. Even Great Britain and Canada have changed to the metric system. It is important, as we know, to make screw threads that are interchangeable in any country in the world. So we are moving toward a metric thread system that can be adopted by all nations. Then a bolt manufactured in the United States could be used to replace a bolt that was manufactured in West Germany.

Let's take a look at the inch threads and metric threads accepted by the International Standards Organizations (ISO). At the present time, there are 57 sizes of

ISO metric threads and 59 sizes of ISO inch threads (which are the same as the Unified National Coarse (UNC).) The thread forms of both the ISO metric and the ISO inch series are identical, as shown in these two diagrams.

THREAD FORM – ISO METRIC AND ISO INCH SERIES


0.250 p
0.375 H
0.250 H
H (FUNDAMENTAL TRIANGLE)
INTERNAL THREAD
p (PITCH)
p (PITCH)
0.125 p
EXTERNAL THREAD
90°
0.375 H
0.375 H
H
R = 0.108 p/0.144 p

Now, if the thread forms for both the ISO metric series and the ISO inch series are identical, then the screws or bolts should be interchangeable – right? WRONG! *The* *threads of the ISO metric series and the ISO inch series (UNC) are not interchangeable.* Even though some of the sizes may appear very close, there will be slight differences in their diameters and in the size of the threads.

The International Fasteners Institute (IFI) has recommended that both the ISO metric sizes and the ISO inch sizes be replaced with 25 metric threads. Most of these IFI trial thread sizes are identical to the ISO metric coarse thread series. They are also the most commonly used sizes.

Standards for manufacturing the IFI trial metric threads, the ISO metric threads (coarse and fine series), and the Unified National (UNC, UNF, and UNEF) can be found in the 20th edition of *Machinery's Handbook*.

Class Discussion

1. What screw-thread system is most commonly used in the United States today?
2. What screw-thread system is most commonly used in most parts of the world today?
3. Are ISO metric and ISO inch threads interchangeable?
4. What are the advantages of standardizing the screw-thread system used throughout the world?
5. What reasons would you give for substituting the 25 IFI sizes for the 57 metric sizes and the 59 inch sizes?
6. Why would European countries insist on metric machine parts when "buying American"?

UNIT VIII – METRIC THREADS

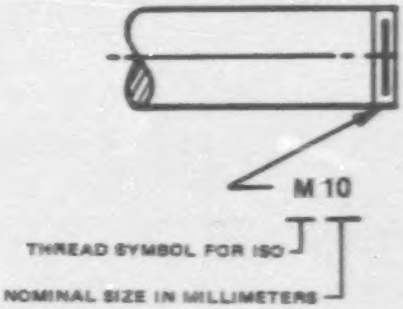
Lesson 2 **Metric Thread Designations**

Objective: You should be able to read a complete designation of a metric thread.

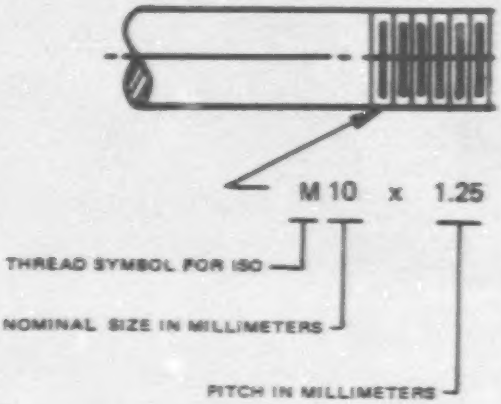
Craftsmen will not only use metric threads in the future; they will also have to "think metric" to work efficiently. "Thinking metric" includes being able to read metric thread designations. Let's start at the beginning.

All metric threads begin with a capital M for metric. Easy so far – OK.

The M is followed by the major or *nominal* diameter (outside diameter) in millimeters. So, an M 12 has a nominal size of 12 millimeters, and an M 10 thread has a nominal size of 10 millimeters. Metric nominal diameters range from 1 to 100 millimeters.


M 10
THREAD SYMBOL FOR ISO
NOMINAL SIZE IN MILLIMETERS

The next part of the thread designation is the *pitch*, which is the distance from the top of one thread to the top of the next. The pitch is also shown in millimeters. The pitch is separated from the nominal diameter by the sign "x." So the thread designation for an M 10 thread with a 1.25 millimeter pitch would read M10x 1.25.


M 10 x 1.25
THREAD SYMBOL FOR ISO
NOMINAL SIZE IN MILLIMETERS
PITCH IN MILLIMETERS

The samples below include the nominal diameter and thread pitch of selected threads from the ISO Metric-Fine Series.

M8x1.0	M24x2.0
M12x1.25	M30x2.0
M16x1.5	M36x3.0
M20x1.5	M42x3.0

There is an exception to the pitch designation. The pitch designation may be omitted from the thread designation for ISO Metric Threads – Coarse Series. In other words, if no pitch designation for an M10 thread is given, then the pitch is 1.5 mm – because 1.5 mm is the pitch for a coarse-series size for a 10 mm diameter thread. The 12 coarse-series threads below include 90% of the metric threads used in manufacturing.

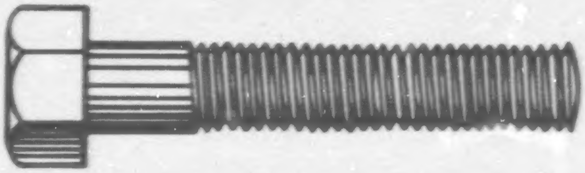
ISO Metric Thread – Coarse Series

Diameter	Pitch
2	0.4
2.5	0.4
3	0.5
4	0.7
5	0.8
6	1.0
8	1.25
10	1.5
12	1.75
16	2.0
20	2.5
24	3.0

So, an M5 thread without a pitch designation would mean a coarse thread with a pitch of 0.8 mm.

PROBLEMS

1. Shown below is an example of an M12 external thread. What is the nominal diameter of this thread? __________



2. The pitch of the above bolt is not listed in the thread designation.

    a. What is the pitch? __________

    b. Is it a coarse-series or a fine-series thread? __________

3. Another bolt has a thread designation of M16x1.5.

   a. What is the nominal diameter? __________

   b. What is the pitch? __________

   c. Is it a coarse-series or fine-series thread? __________

4. A bolt has a thread designation of M24x 2.0.

   a. What is the nominal diameter? __________

   b. What is the pitch? __________

   c. Is it a coarse-series or fine-series thread? __________

5. A bolt has a thread designation of M24.

   a. What is the nominal diameter? __________

   b. What is the pitch? __________

   c. Is it a coarse-series or fine-series thread? __________

6. A bolt has a thread designation of M16x2.0.

   a. What is the nominal diameter? __________

   b. What is the pitch? __________

   c. Is it a coarse-series or fine-series thread? (Think carefully before you answer this question.) __________

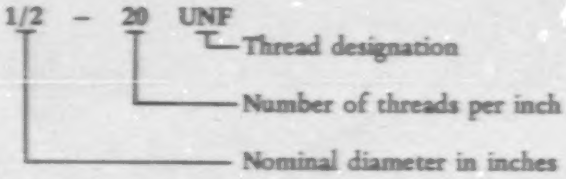
UNIT VIII – METRIC THREADS

Lesson 3 **Thread Identification Chart**

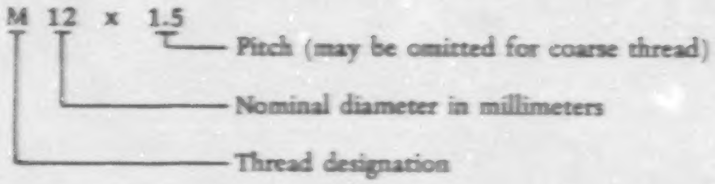
Objective: You should be able to distinguish between metric, American and British threads.

There are several differences in thread designations when comparing the American, metric and British systems. See if you can determine the differences by looking at these examples.

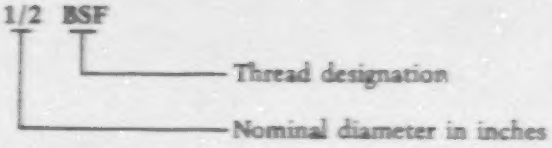
American


1/2 – 20 UNF
Thread designation
Number of threads per inch
Nominal diameter in inches

Metric


M 12 x 1.5
Pitch (may be omitted for coarse thread)
Nominal diameter in millimeters
Thread designation

British


1/2 BSF
Thread designation
Nominal diameter in inches

Check your findings against these differences:

1. The metric designation uses *pitch* where the American system uses *threads per inch*. Pitch is measured from one point on a thread to a corresponding point on the next thread.

2. When the pitch is omitted in metric, that means it is a coarse thread.

3. In the British system, there is no need to indicate the number of threads per inch. There is only one number of threads allocated to each diameter and series.

The Thread Identification Chart in the Appendix will show some other differences. For example:

1. American miniature thread is interchangeable with corresponding sizes of ISO metric.

2. The nominal diameter of metric *pipe* threads (straight and tapered) is the actual measurement of the major diameter of the thread. This is not true with the American and British systems. In those systems, the nominal diameter of the pipe is the inside diameter of the *tube*.

PROBLEMS

1. Give two examples from the chart to show that the American miniature thread (UNM) is interchangeable with corresponding sizes of ISO metric.

2. Write out the thread designation for two threads each for:

    a. Metric
    b. American
    c. British

3. Why does the thread designation for the British system omit the number of threads per inch?

APPENDIX A

THREAD IDENTIFICATION CHART

The task of establishing origin, designation, and size of an unknown thread can be a complicated experience, even if you have all the necessary tools at hand. To make it easier, we have prepared a Thread Identification Chart (T.I.C.) where the three most common threads - American, British and Metric are listed. Just follow these three basic steps: 1. Measure Major Diameter of your thread 2. Count number of threads per one inch length 3. Locate your findings in our T.I.C.

Before going further in this detailed instruction here is a general introduction to Metric and British thread designations. For comparison, the American Standard is included.

AMERICAN: 1/2 - 20 UNF
- 1/2 – Nominal diameter
- 20 – Number of threads per inch
- UNF – Thread designation

METRIC: M 12 x 1.5
- M – Thread designation
- 12 – Nominal diameter
- 1.5 – Pitch {For coarse series pitch may be omitted

BRITISH: 1/2 BSF
- 1/2 – Nominal diameter
- BSF – Thread designation

Designation examples of the various thread series:

ORIGIN	COARSE THREAD	FINE THREAD	EXTRA FINE THD	MINIATURE THD	PIPE - TAPERED THD
AMERICAN	1/4 - 20 UNC	1/4 - 28 UNF	1/4 - 32 UNEF	1.40 UNM	1/4 - 18 NPT
METRIC	M 6	M 6 x 0.75	M 6 x 0.5	M 1.4	M 12 x 1.5 Taper
BRITISH	1/4 BSW	1/4 BSF	None	12 BA	1/4 BSPT

From the above table several designation differences are apparent:

1. *Metric designation uses pitch instead of number of threads per inch. Pitch is the distance from any one point on a thread to a corresponding point on the next thread, measured parallel to the axis.*
2. *Metric coarse thread does not indicate pitch. The absence of pitch means coarse thread series.*
3. *Nominal diameter of Metric pipe threads (straight and tapered) corresponds to the actual measurement of the thread major diameter. This is contrary to American and British designations where nominal diameter of the pipe thread indicates approximate inside diameter of the tube. In the T.I.C., threads are listed in order of increasing size of the major diameter. Due to this American and British pipe threads are in the chart among larger size thread diameters.*
4. *A point of interest is that most European countries still use the inch measuring system in connection with pipe threads. It is actually British thread BSP and BSPT, but the local designation may be different:*
   In France G 1/2 co for tapered pipe thread, G 1/2 cyl for straight pipe thread (G for Gaz)
   In Germany R 1/2 k for tapered pipe thread, R 1/2 for straight pipe thread (R for Rohr - pipe)
5. *In the British system there is no need to indicate the number of threads per inch. All British thread series have only one number of threads per inch allocated to its diameter and series.*
6. *American Miniature thread (UNM) is interchangeable with corresponding sizes of ISO Metric Standardization.*

For a chosen thread size, we follow as our example a metric thread nominal diameter 6 mm with 25½ Thds/Inch which is approx. 1 mm pitch. Correct designation is M 6. This thread is close to the following threads: M 6 x 0.5, M 6 x 0.75, ¼-20 UNC, ¼-28 UNF ¼-32 UNEF, 7/32 BSF, 0 BA, ¼ BSW and ¼ BSF.

Following are step by step instructions on using the T.I.C.:

1. *Use micrometer or caliper to measure Major Diameter (actual outside dia.) of the screw thread. It can be measured in decimal inches or millimetres. Note that thread major dia. is often undersized for clearance.*
   Example in measurement: Approx. .230 Inches or 5.9 mm

Inch Reading: .232"
05.90
Metric Reading: 5.90 mm

2. *Use ruler, caliper or micrometer to count number of threads per inch.*
   Example in counting: Approx. 25 Thds/Inch.
   Since the Metric system does not use Thds/Inch for identification, use the Pitch Conversion Table to convert the counted 25 Thds/Inch to the exact number of 25½ Thds/Inch as equal Pitch 1.
   Pitch Conversion Table is located on T.I.C. at the right margin.

Count of approx. 25 Thds/Inch

PITCH CONVERSION TABLE

THDS/Inch	PITCH
[illegible]	[illegible]
[illegible]	0.9
25½	1
[illegible]	1.25

3. *Using the Basic Major Dia. column in T.I.C. locate the decimal inch dia. Once established, move horizontally to find a match in Thds/Inch or Pitch.*
   Example Major Dia. measured .230 is actually .2362 Inches or 6 mm in Basic Major Dia. column. Moving horizontally to the right are listed two threads: Metric M 6 and British 0 BA

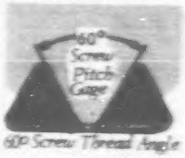
BASIC MAJOR DIA.		METRIC				AMERICAN					BRITISH			
Inch	mm	Nom.Dia.	Std.	Coarse	Fine	Nom.Dia.	UNC	UNF	UNEF	UNM	Nom.Dia.	BA	BSW	BSF
.2188 .2362 .2500	5.56 6 6.35	6	o x	1	0.5, 0.75	1/4	20	28	32		7/32 0 1/4	25½	20	28 26
[illegible]	7	7	[illegible]	1	0.5, 0.75									

Should there be only one thread in this line, the task would be accomplished. Since there is more than one possibility, we have to go back to the example and check its thread angle for final breakdown.

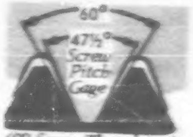
Using metric Screw Pitch Gage we can safely distinguish 60 Degree of metric thread against 47½ Degree of British BA thread angle.

Example in measurement: Metric 60 Degree thread angle.

Example's origin and size is: Metric Screw M 6



60° Screw Thread Angle



60° Screw Thread Angle

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METRIC & M. C. CORP.
ELMSFORD, NY. 10523
(914) . 592 - 4820

THREAD IDENTIFICATION CHART

TO BE USED FOR IDENTIFICATION OF THREE MOST COMMON THREAD SYSTEMS:

METRIC

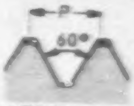
- **M** - Coarse and Fine Thread
  - ● ISO Std. - 1st Choice
  - ●● ISO Std. - 2nd Choice
  - ●●● ISO Std. - 3rd Choice
  - x DIN (German Standard)
- **M** Taper - Metric Pipe Tapered

AMERICAN

- **UNC** - Unified National Coarse
- **UNF** - Unified National Fine
- **UNEF** - Unified National Extra Fine
- **UNM** - Unified National Miniature
- **NPT** - National Pipe Tapered

BRITISH

- **BA** - British Association
- **BSW** - British Std. Whitworth
- **BSF** - British Standard Fine
- **BSP** - British Standard Pipe
- **BSPT** - British Std. Pipe Tapered



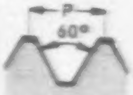
METRIC:
M, MPT

BASIC MAJOR DIAMETER	
Inch	mm
.0118	0.3
.0118	0.3
.0138	0.35
.0146	0.37
.0157	0.4
.0165	0.42
.0177	0.45
.0189	0.48
.0197	0.5
.0209	0.53
.0213	0.54
.0217	0.55
.0236	0.6
.0244	0.62
.0276	0.7
.0311	0.79
.0315	0.8
.0340	0.86
.0354	0.9
.0394	1
.0433	1.1
.0470	1.19
.0472	1.2
.0512	1.3
.0551	1.4
.0591	1.5
.0600	1.52
.0629	1.6
.0669	1.7
.0709	1.8
.0730	1.85
.0748	1.9
.0787	2
.0860	2.18
.0866	2.2
.0906	2.3
.0984	2.5
.0990	2.51
.1024	2.6
.1102	2.8
.1120	2.84
.1181	3
.1250	3.18
.1260	3.20
.1380	3.5
.1417	3.60
.1575	4
.1614	4.10
.1640	4.17
.1772	4.5
.1850	4.70
.1875	4.76
.1900	4.83
.1969	5
.2087	5.30
.2160	5.49
.2165	5.5
.2188	5.56
.2362	6
.2500	6.35
.2756	7
.2812	7.14
.3125	7.94

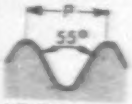
METRIC			
NOM. DIA.	STD.	PITCH IN mm	
mm		Coarse	Fine
0.3	x	0.075	
0.3	●	0.08	
0.35	●●	0.09	
0.4	● x	0.1	
0.45	●●	0.1	
0.5	● x	0.125	
0.55	●●	0.125	
0.6	● x	0.15	
0.7	●● x	0.175	
0.8	● x	0.2	
0.9	●● x	0.225	
1	● x	0.25	0.2
1.1	●●	0.25	0.2
1.2	● x	0.25	0.2
1.4	●● x	0.3	0.2
1.5		0.3	
1.6	●	0.35	0.2
1.7	x	0.35	0.2,0.25
1.8	●●	0.35	0.2
2	● x	0.4	0.25,0.35
2.2	●●	0.45	0.25
2.3	x	0.4	0.25,0.35
2.5	●	0.45	0.35
2.6	x	0.45	0.25,0.35
3	● x	0.5	0.35, 0.6
3.5	●● x	0.6	0.35, 0.5
4	● x	0.7	0.5, 0.75
4.5	●●	0.75	0.5
5	● x	0.8	0.5,0.75,0.9
5.5	●●●	0.9	0.5
6	● x	1	0.5, 0.75
7	●●● x	1	0.5, 0.75

AMERICAN				
NOMINAL DIA.	THREADS PER INCH			
	UNC	UNF	UNEF	UNM
.30 mm				318
.35 mm				282
.40 mm				254
.45 mm				254
.50 mm				203
0000		160		
.55 mm				203
.60 mm				169
.70 mm				145
.80 mm				127
000		120		
.90 mm				113
1.00 mm				102
1.10 mm				102
00		90	96	
1.20 mm				102
1.40 mm				85
0		80		
1	64	72		
2	56	64		
3	48	56		
4	40	48		
5	40	44		
6	32	40		
8	32	36		
10	24	32		
12	24	28	32	
1/4	20	28	32	
5/16	18	24	32	

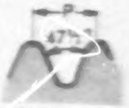
BRITISH			
NOMINAL DIA.	THREADS / INCH		
	BA	BSW	BSF
22	254		
21	231		
20	211¾		
19	181½		
18	169¼		
17	149½		
16	133¾		
15	121		
14	110½		
13	101½		
12	90¾		
11	82		
10	72½		
9	65		
8	59		
7	53		
6	48		
1/8		40	
5	43		
4	38½		
3	34¾		
2	31¼		
3/16		24	32
1	28¼		
7/32			28
0	25½		
1/4		20	26
9/32			26
5/16		18	22



AMERICAN:
UNC, UNF,
UNEF, UNM,



BRITISH:
BSW, BSF,
BSP, BSPT



BRITISH: BA

PITCH CONVERSION TABLE

Approx. Threads Per Inch	Pitch mm
338¾	0.075
317½	0.08
282¼	0.09
254	0.1
203¼	0.125
169¼	0.15
145¼	0.175
127	0.2
101½	0.25
84¾	0.3
72½	0.35
63½	0.4
56½	0.45
50¾	0.5
42¼	0.6
36¼	0.7
33¾	0.75
31¾	0.8
28¼	0.9
25½	1
20¼	1.25
17	1.5
14½	1.75
12¾	2
10¼	2.5
8½	3
7¼	3.5
6¼	4
5¾	4.5
5	5
4½	5.5
4¼	6

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THREAD IDENTIFICATION CHART - CONTINUED:

BASIC MAJOR DIAMETER		METRIC					AMERICAN					BRITISH				
		NOM.DIA.	STD.	PITCH IN mm			NOMINAL	THREADS PER INCH				NOMINAL	THREADS PER INCH			
inch	mm	mm		Coarse	FINE	■Taper	DIA.	UNC	UNF	UNEF	NPT	DIA.	BSW	BSF	BSP	BSPT
.3125	7.94						1/16				27					
.3150	8	8	● ×	1.25	0.5, 0.75, 1	1										
.3543	9	9	●●●●	1.25	0.75, 1											
.3750	9.53						3/8	16	24	32		3/8	16	20		
.3830	9.73											1/8			28	28
.3937	10	10	● ×	1.5	0.75, 1, 1.25	1										
.4050	10.29						1/8				27					
.4331	11	11	●●●●	1.5	0.75, 1, 1.25											
.4375	11.11						7/16	14	20	28		7/16	14	18		
.4724	12	12	● ×	1.75	1, 1.25, 1.5	1.5										
.5000	12.70						1/2	13	20	28		1/2	12	16		
.5180	13.16											1/4			19	19
.5400	13.72						1/4				18					
.5512	14	14	●● ×	2	1, 1.25, 1.5											
.5625	14.29						9/16	12	18	24		9/16	12	16		
.6250	15.88						5/8	11	18	24		5/8	11	14		
.6299	16	16	● ×	2	1, 1.5	1.5										
.6560	16.66											3/8			19	19
.6750	17.15						3/8				18					
.6875	17.46						11/16			24		11/16	11	14		
.7087	18	18	●● ×	2.5	1, 1.5, 2	1.5										
.7500	19.05						3/4	10	16	20		3/4	10	12		
.7874	20	20	● ×	2.5	1, 1.5, 2	1.5										
.8125	20.64						13/16			20		13/16		12		
.8250	20.96											1/2			14	14
.8400	21.34						1/2				14					
.8661	22	22	●● ×	2.5	1, 1.5, 2	1.5										
.8750	22.23						7/8	9	14	20		7/8	9	11		
.9020	22.91											5/8			14	14
.9375	23.81						15/16			20						
.9449	24	24	● ×	3	1, 1.5, 2											
1.0000	25.40						1	8	12	20		1	8	10		
1.0236	26	26	●●●●		1.5	1.5										
1.0410	26.44											3/4			14	14
1.0500	26.67						3/4				14					
1.0625	26.99						1 1/16			18						
1.0630	27	27	●● ×	3	1, 1.5, 2											
1.1250	28.58						1 1/8	7	12	18		1 1/8	7	9		
1.1811	30	30	● ×	3.5	1, 1.5, 2, 3											
1.1875	30.16						1 3/16			18						
1.1890	30.20											7/8			14	14
1.2500	31.75						1 1/4	7	12	18		1 1/4	7	9		
1.2598	32	32	●●●×		1.5, 2											
1.2992	33	33	●● ×	3.5	1.5, 2, 3											
1.3090	33.25											1			11	11
1.3125	33.34						1 5/16			18						
1.3150	33.40						1				11½					
1.3750	34.93						1 3/8	6	12	18		1 3/8		8		
1.3780	35	35	●●●×		1.5											
1.4173	36	36	● ×	4	1.5, 2, 3											
1.4375	36.51						1 7/16			18						
1.4920	37.98											1 1/8			11	
1.4961	38	38	●●●×		1.5											
1.5000	38.10						1 1/2	6	12	18		1 1/2	6	8		
1.5354	39	39	●● ×	4	1.5, 2, 3											
1.5625	39.69						1 9/16			18						
1.5748	40	40	●●●×		1.5, 2, 3											
1.6250	41.28						1 5/8			18		1 5/8		8		
1.6500	41.91											1 1/4			11	11
1.6535	42	42	● ×	4.5	1.5, 2, 3, 4											
1.6600	42.16						1 1/4				11½					
1.6875	42.86						1 11/16			18						
1.7450	44.32											1 3/8			11	
1.7500	44.45						1 3/4	5				1 3/4	5	7		
1.7717	45	45	●● ×	4.5	1.5, 2, 3, 4											
1.8820	47.80											1 1/2			11	11
1.8898	48	48	● ×	5	1.5, 2, 3, 4											
1.9000	48.26						1 1/2				11½					
1.9685	50	50	●●●●		1.5, 2, 3											
2.0000	50.80						2	4½				2	4½	7		
2.0472	52	52	●● ×	5	1.5, 2, 3, 4											
2.2047	56	56	● ×	5.5	1.5, 2, 3, 4											
2.2500	57.15						2 1/4	4½				2 1/4	4	6		
2.3470	59.61											2			11	11
2.3622	60	60	●● ×	5.5	1.5, 2, 3, 4											
2.3750	60.33						2				11½					
2.5000	63.50						2 1/2	4				2 1/2	4	6		
2.5197	64	64	● ×	6	1.5, 2, 3, 4											

APPENDIX B

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. – TWO PENNSYLVANIA PLAZA – NEW YORK, NEW YORK 10001

LAND SEA AIR SPACE

STANDARD J390

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DUAL DIMENSIONING — SAE J390

SAE Standard

Report of the Drawing Standards Committee and Metric Advisory Committee approved July 1970.

1. GENERAL

This document establishes a uniform method of combining U.S. customary (inch) units and metric units of measure on the same engineering drawing. In this document "metric units" means the International System of Units (abbreviated SI) as described in ISO Recommendation R 1000, which includes certain units in addition to the formal SI. Included is guidance for converting from one system to the other while maintaining interchangeability.

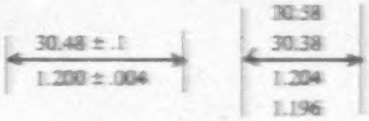
2. STANDARD UNITS

2.1 U.S. UNITS - The U.S. customary unit for linear dimensions is the inch with decimal dimensioning preferred. (One inch equals 25.4 millimeters, exactly.)

2.2 METRIC UNITS - The metric unit, on engineering drawings, for linear dimensions is the millimeter.

2.3 IDENTIFICATION OF UNITS - The inch and millimeter dimensions must be identified, one from the other as follows:

2.3.1 Preferred Method - Dimensions shall be identified by relative position with the millimeter dimensions above or to the left of the inch dimensions.



30.48 ± 0.1/1.200 ± .004

2.3.2 Alternative Methods - It will be permissible to use one of the following alternative methods of identification in place of 2.3.1.

(a) Position method as in 2.3.1 except with inch dimension above or to the left of the millimeter dimension -

(b) Square brackets [ ] surrounding the millimeter dimensions, placed adjacent to the inch dimensions (position optional).

(c) Square brackets [ ] surrounding the inch dimensions, placed adjacent to the millimeter dimensions (position optional).

2.3.3 Only one of the above methods of identification of units may be used throughout a single drawing. Each drawing shall illustrate how to identify the inch and millimeter dimensions, by a note adjacent to or within the title block, such as:

$$\frac{\text{MILLIMETER}}{\text{INCH}}\text{; MILLIMETER/INCH,}$$

$$\frac{\text{INCH}}{\text{[MILLIMETER]}}\text{; INCH [MILLIMETER], etc.}$$

2.3.4 In converting existing drawings to dual-dimensioning, space limitations may sometimes make it impractical to locate dimensions as required for identification by position. In these cases it is permissible to show the converted dimension in a nearby associated location identified with the symbol mm or IN.

2.3.5 Units other than linear and all units used for other than normal drawing dimensions (i.e. notes or text) shall be identified with the appropriate symbol.

Examples: 13.6 Nm/10 LBF FT
OVERHANG LIMITED TO 12.7 mm/.50 IN

2.4 COMMON UNITS - Some units can be stated so that the call out will satisfy the units of both systems. That is, .006 in. per inch or 0.006 mm per millimeter can both be expressed simply as a ratio, 0.006:1, or in a note, such as TAPER 0.006:1.

2.5 ANGLES - Angular dimensions need no conversion. Angles stated in degrees and decimals of a degree or in degrees, minutes, and seconds are common to the inch and metric systems of measurement.

2.6 NOMINAL DESIGNATIONS - Nominal designations such as thread sizes and tire sizes will not be converted.

3. PRINCIPLES

3.1 MILLIMETER DIMENSIONING PRACTICES

3.1.1 A zero precedes a decimal point in a millimeter value of less than one.

Example: 0.13

3.1.2 Where unilateral tolerancing is used and either the plus or minus value is nil, this value shall be expressed by a single zero only.

Example:

$$32^{\;0}_{-0.02}\,;\quad 32^{+0.02}_{\;0}$$

3.1.3 Nonsignificant zeros are not shown after the decimal point, in the composition of a millimeter value, except as follows:

(a) Where limit dimensioning is used and either the maximum or minimum dimension has digits following the decimal point, the other value shall have zeros added for uniformity.

$$\text{Example: } \frac{25.90}{25.45} \text{ not } \frac{25}{25.45}$$

(b) Where bilateral tolerancing is used, both the plus and minus values shall have the same number of decimal places, using zeros where necessary.

$$\text{Example: } 32^{+0.25}_{-0.10} \text{ not } 32^{+0.25}_{-0.1}$$

3.1.4 The symbol ϕ and the abbreviation DIA are synonymous, defining a feature as diametral. Either may be used on a dual dimension drawing; however, both shall not be used on the same drawing. The application of either the symbol ϕ or DIA is self explanatory. The symbol ϕ may either precede or follow the dimension.

$$\text{Example: } \phi\frac{25.4}{1.00} \text{ or } \frac{25.4}{1.00}\phi$$

3.1.5 The decimal sign for metric values shall be same as that used for the inch decimal dimension, a dot (.).

3.1.6 Commas shall not be used to denote thousands in either inch or metric values.

Example: 32541 not 32,541

4. APPLICATION

4.1 NEW DRAWINGS - Dual dimensioning of new drawings is facilitated if all dimensions are shown in decimals.

4.2 GENERAL TOLERANCES - General tolerances usually expressed on a drawing as part of the format or as a general note shall be dual dimensioned.

4.3 SYMBOLS - Geometric characteristic symbols for form and position and the related tolerancing procedure are recommended to be used on dual dimensioned drawings. See ANSI Y14.5-1966.

4.3.1 Dual dimensioned drawings shall specify, by the ISO symbol as shown in Fig. 7, the angle of projection used. Although first angle projection is commonly used in countries where the metric measurement system is standard, it is recommended that third angle projection be used on dual dimensioned drawings that follow this document.

5. CONVERSION OF TOLERANCED LINEAR DIMENSIONS

5.1 CONVERSION TABLES - Refer to Appendix A, Tables and Charts, for conversion tables of inch to millimeter values and millimeter to inch values.

TOTAL TOLERANCE IN INCHES		MILLIMETER CONVERSION ROUNDED TO
AT LEAST	LESS THAN	
.00004	.0004	4 DECIMAL PLACES
.0004	.004	3 DECIMAL PLACES
.004	.04	2 DECIMAL PLACES
.04	.4	1 DECIMAL PLACE
.4 AND OVER		WHOLE MM

FIG. 1

TOTAL TOLERANCE IN MILLIMETERS		INCH CONVERSION ROUNDED TO
AT LEAST	LESS THAN	
0.002	0.02	5 DECIMAL PLACES
0.02	0.2	4 DECIMAL PLACES
0.2	2	3 DECIMAL PLACES
2 AND OVER		2 DECIMAL PLACES

FIG. 2

5.2 ACCURACY OF CONVERTED VALUE - The dimension which is equal to or which is acceptable as the substitute for the original dimension, whether inch or millimeter, should be shown to the number of decimal places so as to maintain interchangeability. Figs. 1 and 2 provide for a round off of the conversion to dimensions that are practical for use. After conversion, judgement must be applied to determine that the error in the round off does not affect interchangeability. Error can be reduced by retaining another decimal place in the converted dimension. Interchangeability can be positively assured by rounding the limits of a dimension inward which will result in a smaller total tolerance and may affect production costs.

5.2.1 It is recognized that some dimensions may require a different accuracy of round off than contained in Figs. 1 and 2. In such cases, modifications to the tabulated values may be used. Dimensions and tolerances should always be governed by design intent, and should not be restrictive for the simple reason of satisfying a mathematical conversion.

5.3 INTERCHANGEABILITY CONSIDERATIONS - There are two basic methods for determining the actual dimensioned value that will provide the interchangeability required and that will permit the acceptable fit of parts produced from dual dimensioned drawings. Method A rounds to value nearest to the limits of the tolerance and Method B rounds to values always inside the tolerance limits.

5.3.1 Using Method A, a dimension is rounded off by following the standard round off rule (see SAE J916, Paragraph 5) and Fig. 1 or Fig. 2. The limits converted by this method, considered as being acceptable for interchangeability, serve as a basis for inspection.

5.3.2 Using Method B, a dimension is rounded off systematically inside the tolerance limits of the dimension. The converted limits never exceed the original limits. This method must be employed when the original limits must be respected, absolutely. This method allows components that are made to the converted limits to be inspected by using the gages that were provided for the original components. Method B may substantially reduce the tolerance and there[illegible] cost and producibility.

[illegible] interchangeability consideration based upon the [illegible] known condition may require the application of both Method A and B to the same dimension. Assembly of mating parts depends upon a "go" condition at the maximum material limits of the parts. The minimum material limits which are determined by the respective tolerances are often not as critical from a functional standpoint. Accordingly, it may be desirable to employ a combination of Methods A and B in certain conversions by using Method B for the maximum material limits and Method A for the minimum material limits. Alternatively, it may be desirable to round automatically the converted minimum material limits outside the original limits to provide greater tolerances for manufacturing.

5.4 CONVERSION OF INCHES TO MILLIMETERS

5.4.1 Method A – The use of this method guarantees that even in the most unfavorable cases neither of the two original limits will be exceeded (or diminished) by more than 4.9% of the tolerance with limit dimensions or 9.8% of the tolerance with plus and minus toleranced dimensions. In plus and minus toleranced dimensions the maximum error shown can only be introduced into one limit of the dimension. The total tolerance may be increased or decreased a maximum of 9.8% with either limit dimensioning or plus and minus toleranced dimensions. See Fig. 3 for maximum limit error in inches.

METHOD A - INCH TO MILLIMETER CONVERSION		
NO. OF PLACES RETAINED IN ROUNDED MM CONVERSION	MAX LIMIT ERROR IN INCHES	
	LIMIT DIMENSIONS	PLUS & MINUS TOLERANCED DIMENSIONS
4	.000002	.000004
3	.00002	.00004
2	.0002	.0004
1	.002	.004
0	.02	.04

FIG. 3

5.4.1.1 Limit Dimensions

(a) Convert the two values exactly into millimeters by means of the conversion factor one inch equals 25.4 mm.

(b) Round off the results obtained to the nearest rounded value as indicated in Fig. 1, depending on the original total tolerance in inches.

Example: 1.966
1.934

Conversion into millimeters gives:

49.9364
49.1236

The total tolerance equals .032 in. and lies between .004 and .04 in., and the conversion is rounded to the nearest 0.01 mm. This results in limits as follows:

49.94
49.12

5.4.1.2 Plus and Minus Toleranced Dimensions

(a) Convert the dimension and each deviation exactly into millimeters by means of the conversion factor 1 in. equals 25.4 mm exactly.

(b) Round off the results obtained to the nearest rounded value as indicated in Fig. 1 depending on the original total tolerance in inches.

Examples:

(1) Bilateral Toleranced Dimension

.375 ± .005

Conversion into millimeters gives:

9.5250 ± 0.1270

The total tolerance equals .010 in. and thus lies between .004 and .04 in. and the conversion is rounded to the nearest 0.01 mm. This results in a final dimension as follows:

9.52 ± 0.13
(See 5.3.1 for round off rules)

(2) Unilateral Toleranced Dimension

$$1.250^{+.000}_{-.005}$$

Conversion into millimeters gives:

$$31.7500^{\;0}_{-0.1270}$$

The total tolerance equals .005 in. and lies between .004 and .04 in. and the conversion is rounded to the nearest 0.01 mm. This results in a final dimension as follows:

$$31.75^{\;0}_{-0.13}$$

5.4.2 Method B – This method must be employed when the original limits may not be violated even slightly. Method

B is only directly applicable to limit dimensions, see 5.4.2.2. With limit dimensions Method B may increase the lower limit or decrease the upper limit a maximum of 9.8% of the total tolerance. Method B may decrease the total tolerance a maximum of 19.7%. See Fig. 4 for maximum limit error in inches.

METHOD B - INCH TO MILLIMETER CONVERSION	
NO. OF PLACES RETAINED IN ROUNDED MM CONVERSION	MAX LIMIT ERROR IN INCHES LIMIT DIMENSIONS
4	.000004
3	.00004
2	.0004
1	.004
0	.04

FIG. 4

5.4.2.1 Limit Dimensions

(a) Convert the two values exactly into millimeters by means of the conversion factor one inch equals 25.4 mm.

(b) Round off each limit toward the interior of the tolerance, that is, to the next lower value for the upper limit and to the next higher value for the lower limit.

Example: 1.966
1.934

Conversion into millimeters gives:

49.9364
49.1236

The total tolerance equals .032 in. and lies between .004 and .04 in., and the conversion is rounded inward to the nearest 0.01 mm. This results in limits as follows:

49.93
49.13

5.4.2.2 Plus and Minus Toleranced Dimensions – Method B is not directly applicable to plus and minus toleranced dimensions. If method B is desired, the dimension should be changed to limits and conversion performed as in 5.4.2.1.

Example:

.375 ± .005

Calculate the maximum and minimum limits in inches

.380
.370

Conversion into millimeters gives:

9.652
9.398

The total tolerance equals .010 in. and lies between .004 and .04 in. and the conversion is rounded inward to the nearest 0.01 mm, resulting in limits as follows:

9.65
9.40

5.5 CONVERSION OF MILLIMETERS TO INCHES

5.5.1 Method A – The use of this method guarantees that even in the most unfavorable cases neither of the two original limits will be exceeded (or diminished) by more than 6.4% of the tolerance with limit dimensions or 12.7% of the tolerance with plus and minus toleranced dimensions. In plus and minus toleranced dimensions the maximum error shown can only be introduced into one limit of the dimension. The total tolerance may be increased or decreased a maximum of 12.7% with either limit dimensioning or plus and minus toleranced dimensions. See Fig. 5 for maximum limit error in inches.

METHOD A - MILLIMETER TO INCH CONVERSION		
NO. OF PLACES RETAINED IN ROUNDED INCH CONVERSION	MAX LIMIT ERROR IN INCHES	
	LIMIT DIMENSIONS	PLUS & MINUS TOLERANCED DIMENSIONS
5	.000005	.00001
4	.00005	.0001
3	.0005	.001
2	.005	.01
1	.05	.1

FIG. 5

5.5.1.1 Limit Dimensions

(a) Convert the two values into inches by means of the conversion factor 1 mm equals 1/25.4 in. to at least two places more than required in the rounded conversion.

(b) Round off the results obtained to the nearest rounded values as indicated in Fig. 2, depending on the original total tolerance in millimeters.

Example:

49.6
48.8

Conversion into inches gives:

1.95275
1.92125

The total tolerance equals 0.8 mm and lies between 0.2 and 2.0 mm, and the conversion is rounded to the nearest .001 in. This results in limits as follows:

1.953
1.921

5.5.1.2 Plus and Minus Toleranced Dimensions

(a) Convert the dimension and each deviation into inches by means of the conversion factor 1 mm equals 1/25.4 in., to at least two places more than required in the rounded conversion.

(b) Round off the results obtained to the nearest rounded value as indicated in Fig. 2 depending on the original total tolerance in millimeters.

Examples:

(a) Bilateral Toleranced Dimension

$$73.43 \pm 0.02$$

Conversion into inches gives:

$$2.890944 \pm .000787$$

The total tolerance equals 0.04 mm and lies between 0.02 and 0.2 mm, and the conversion is rounded to the nearest .0001 in. This results in final dimensions as follows:

$$2.8909 \pm .0008$$

(b) Unilateral Toleranced Dimension

$$75^{+0.3}_{0}$$

Conversion into inches gives:

$$2.95276^{+.01181}_{-.000}$$

The total tolerance equals 0.3 mm and lies between 0.2 and 2 mm, and the conversion is rounded to the nearest .001 in. This results in a dimension as follows:

$$2.953^{+.012}_{-.000}$$

5.5.2 Method B – This method must be employed when the original limits may not be violated even slightly. Method B is only directly applicable to limit dimensions, see 5.5.2.2. With limit dimensions, Method B may increase the lower limit or decrease the upper limit a maximum of 12.7% of the total tolerance. Method B may decrease the total tolerance a maximum of 25.4%. See Fig. 6 for maximum limit error in inches.

5.5.2.1 Limit Dimensions

(a) Convert the two values into inches by means of the conversion factor 1 mm equals 1/25.4 in., to at least two places more than required in the rounded conversion.

(b) Round off each limit toward the interior of the tolerance, that is, to the next lower value for the upper limit and to the next higher value for the lower limit.

METHOD B - MILLIMETER TO INCH CONVERSION	
NO. OF PLACES RETAINED IN ROUNDED INCH CONVERSION	MAX LIMIT ERROR IN INCHES LIMIT DIMENSIONS
5	.00001
4	.0001
3	.001
2	.01
1	.1

FIG. 6

Example:

49.6
48.8

Conversion into inches gives:

1.95275
1.92125

The total tolerance equals 0.8 mm and lies between 0.2 and 2.0 mm, and the conversion is rounded inward to the nearest .001 in. This results in limits as follows:

1.952
1.922

5.5.2.2 Plus and Minus Toleranced Dimensions – Method B is not directly applicable to plus and minus toleranced dimensions. If Method B is desired, the dimensions should be changed to limits and conversion performed as in 5.5.2.1.

Example:

$$73.43 \pm 0.02$$

Calculate the maximum and minimum limits in millimeters:

73.45
73.41

Conversion into inches gives:

2.891732
2.890157

The total tolerance equals 0.04 mm and lies between 0.02 and 0.2 mm, and the conversion is rounded inward to the nearest .0001 in. This results in limits as follows:

2.8917
2.8902

6. BASIC DIMENSIONS

The conversion of a basic dimension shall be rounded off to three places if converted to millimeters and five places if converted to inches. This will result in a possible conversion error always less than:

inch-millimeter	.00002 in.
millimeter-inch	.000005 in.

7. POSITION AND FORM TOLERANCE

Since the position and form tolerance is a total zone tolerance, Figs. 1 and 2 should determine the number of decimal places in the converted value and either Method A or Method B should be used to determine the degree of accuracy permitted as it relates to the product and the interchangeability requirements.

8. TOLERANCED DIMENSION APPLIED TO A NONTOLERANCED POSITION DIMENSION

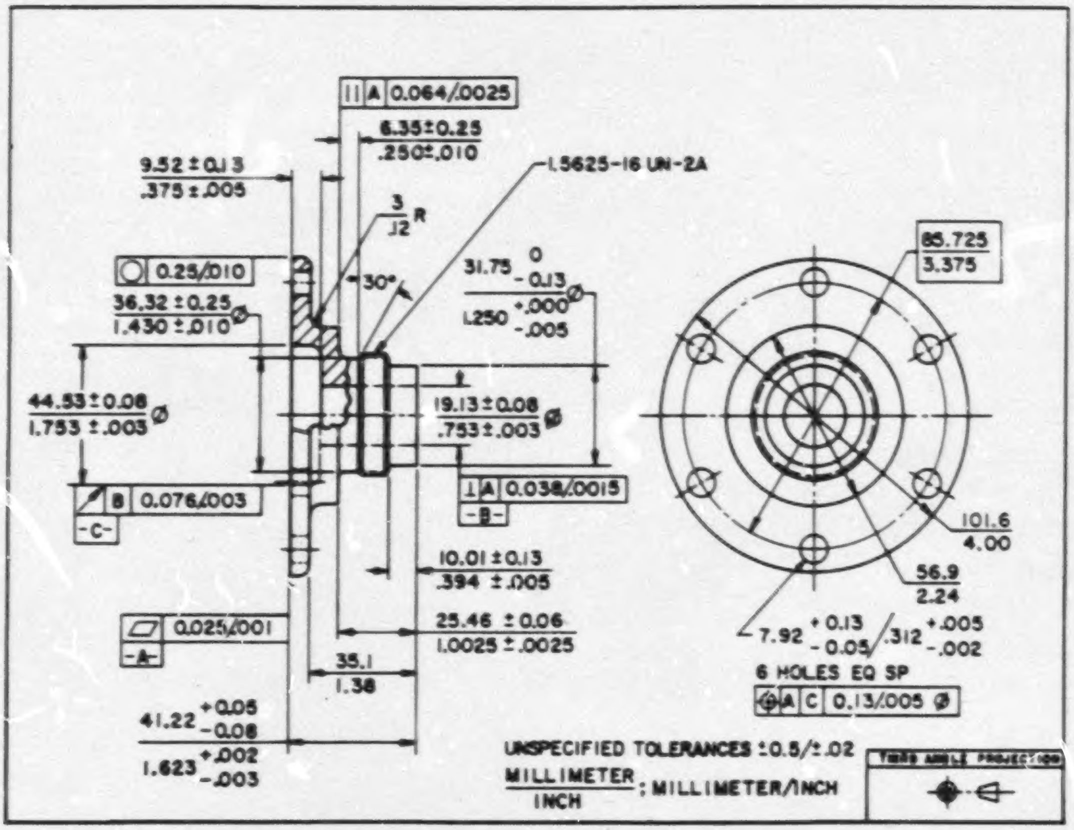
If a toleranced dimension is located in a plane, the position of which is given by a nontoleranced basic dimension, such as when dimensioning certain conical surfaces, proceed as follows:

(a) Round off the basic dimension to the nearest convenient value.

(b) Calculate exactly, in the converted unit of measurement, new maximum and minimum limits of the specified tolerance zone, in the new plane defined by the new basic dimension.

(c) Round off these limits in conformity with the present rules.

Example: A cone of taper .05:1 has a diameter of 1.000 ± .002 in. in a reference plane located by



// A 0.064/.0025
6.35±0.25
.250±.010
9.52±0.13
.375±.005
1.5625-16 UN-2A
3/32 R
0.25/.010
30°
31.75 0 -0.13
1.250 +.000 -.005
36.32±0.25
1.430±.010
44.53±0.08
1.753±.003
19.13±0.08
.753±.003
B 0.076/.003
-C-
⊥ A 0.038/.0015
-B-
10.01±0.13
.394±.005
0.025/.001
-A-
25.46 ±0.06
1.0025±.0025
35.1
1.38
41.22 +0.05 -0.08
1.623 +.002 -.003
85.725
3.375
101.6
4.00
56.9
2.24
7.92 +0.13 -0.05 / .312 +.005 -.002
6 HOLES EQ SP
A C 0.13/.005 Ø
UNSPECIFIED TOLERANCES ±0.5/±.02
MILLIMETER / INCH ; MILLIMETER/INCH
THIRD ANGLE PROJECTION

the nontoleranced dimension .9300 in. By virtue of the taper of the cone, the limits of the tolerance zone depend on the position of the reference plane. Consequently, if the dimension .9300 in. equals 23.6220 mm is rounded off to 23.600 mm (a reduction of 0.022 mm) each of the two original limits, when converted exactly into millimeters must be corrected by 0.022 × 0.05 = 0.0011 mm, in the appropriate sense, before being rounded off.

9. DRAWING APPLICATION

The illustration shown in Fig. 7 is an example of how the application of the preceding instructions could apply. With the addition of a design and drafting facility title block and applicable notes, this illustration could reflect a typical dual dimensioned drawing. All linear dimensions and related tolerances follow Fig. 1 for the number of decimal places in the conversion round off and Method A for interchangeability consideration.

TABLES AND CHARTS

TABLE 1A—CONVERSION FROM DECIMAL INCHES TO MILLIMETERS

in	mm	in	mm	in	mm
1	25.4	36	914.4	71	1 803.4
2	50.8	37	939.8	72	1 828.8
3	76.2	38	965.2	73	1 854.2
4	101.6	39	990.6	74	1 879.6
5	127.0	40	1 016.0	75	1 905.0
6	152.4	41	1 041.4	76	1 930.4
7	177.8	42	1 066.8	77	1 955.8
8	203.2	43	1 092.2	78	1 981.2
9	228.6	44	1 117.6	79	2 006.6
10	254.0	45	1 143.0	80	2 032.0
11	279.4	46	1 168.4	81	2 057.4
12	304.8	47	1 193.8	82	2 082.8
13	330.2	48	1 219.2	83	2 108.2
14	355.6	49	1 244.6	84	2 133.6
15	381.0	50	1 270.0	85	2 159.0
16	406.4	51	1 295.4	86	2 184.4
17	431.8	52	1 320.8	87	2 209.8
18	457.2	53	1 346.2	88	2 235.2
19	482.6	54	1 371.6	89	2 260.6
20	508.0	55	1 397.0	90	2 286.0
21	533.4	56	1 422.4	91	2 311.4
22	558.8	57	1 447.8	92	2 336.8
23	584.2	58	1 473.2	93	2 362.2
24	609.6	59	1 498.6	94	2 387.6
25	635.0	60	1 524.0	95	2 413.0
26	660.4	61	1 549.4	96	2 438.4
27	685.8	62	1 574.8	97	2 463.8
28	711.2	63	1 600.2	98	2 489.2
29	736.6	64	1 625.6	99	2 514.6
30	762.0	65	1 651.0	100	2 540.0
31	787.4	66	1 676.4		
32	812.8	67	1 701.8		
33	838.2	68	1 727.2		
34	863.6	69	1 752.6		
35	889.0	70	1 778.0		

NOTE: All values in this table are exact.

TABLE 1B—CONVERSION FROM FRACTIONAL INCHES TO MILLIMETERS

in		mm	in		mm
1/64	0.015 625	0.396 875	33/64	0.515 625	13.096 875
1/32	0.031 250	0.793 750	17/32	0.531 250	13.493 750
3/64	0.046 875	1.190 625	35/64	0.546 875	13.890 625
1/16	0.062 500	1.587 500	9/16	0.562 500	14.287 500
5/64	0.078 125	1.984 375	37/64	0.578 125	14.684 375
3/32	0.093 750	2.381 250	19/32	0.593 750	15.081 250
7/64	0.109 375	2.778 125	39/64	0.609 375	15.478 125
1/8	0.125 000	3.175 000	5/8	0.625 000	15.875 000
9/64	0.140 625	3.571 875	41/64	0.640 625	16.271 875
5/32	0.156 250	3.968 750	21/32	0.656 250	16.668 750
11/64	0.171 875	4.365 625	43/64	0.671 875	17.065 625
3/16	0.187 500	4.762 500	11/16	0.687 500	17.462 500
13/64	0.203 125	5.159 375	45/64	0.703 125	17.859 375
7/32	0.218 750	5.556 250	23/32	0.718 750	18.256 250
15/64	0.234 375	5.953 125	47/64	0.734 375	18.653 125
1/4	0.250 000	6.350 000	3/4	0.750 000	19.050 000
17/64	0.265 625	6.746 875	49/64	0.765 625	19.446 875
9/32	0.281 250	7.143 750	25/32	0.781 250	19.843 750
19/64	0.296 875	7.540 625	51/64	0.796 875	20.240 625
5/16	0.312 500	7.937 500	13/16	0.812 500	20.637 500
21/64	0.328 125	8.334 375	53/64	0.828 125	21.034 375
11/32	0.343 750	8.731 250	27/32	0.843 750	21.431 250
23/64	0.359 375	9.128 125	55/64	0.859 375	21.828 125
3/8	0.375 000	9.525 000	7/8	0.875 000	22.225 000
25/64	0.390 625	9.921 875	57/64	0.890 625	22.621 875
13/32	0.406 250	10.318 750	29/32	0.906 250	23.018 750
27/64	0.421 875	10.715 625	59/64	0.921 875	23.415 625
7/16	0.437 500	11.112 500	15/16	0.937 500	23.812 500
29/64	0.453 125	11.509 375	61/64	0.953 125	24.209 375
15/32	0.468 750	11.906 250	31/32	0.968 750	24.606 250
31/64	0.484 375	12.303 125	63/64	0.984 375	25.003 125
1/2	0.500 000	12.700 000	1	1.000 000	25.400 000

NOTE: All values in table are exact.

TABLE 3—CONVERSION FROM MILLIMETRES TO INCHES

mm	in	mm	in	mm	in
1	0.039 370 08	36	1.417 322 8	71	2.795 275 6
2	0.078 740 16	37	1.456 692 9	72	2.834 645 7
3	0.118 110 24	38	1.496 063 0	73	2.874 015 7
4	0.157 480 31	39	1.535 433 1	74	2.913 385 8
5	0.196 850 39	40	1.574 803 1	75	2.952 755 9
6	0.236 220 47	41	1.614 173 2	76	2.992 126 0
7	0.275 590 55	42	1.653 543 3	77	3.031 496 1
8	0.314 960 63	43	1.692 913 4	78	3.070 866 1
9	0.354 330 71	44	1.732 283 5	79	3.110 236 2
10	0.393 700 8	45	1.771 653 5	80	3.149 606 3
11	0.433 070 9	46	1.811 023 6	81	3.188 976 4
12	0.472 440 9	47	1.850 393 7	82	3.228 346 5
13	0.511 811 0	48	1.889 763 8	83	3.267 716 5
14	0.551 181 1	49	1.929 133 9	84	3.307 086 6
15	0.590 551 2	50	1.968 503 9	85	3.346 456 7
16	0.629 921 3	51	2.007 874 0	86	3.385 826 8
17	0.669 291 3	52	2.047 244 1	87	3.425 196 8
18	0.708 661 4	53	2.086 614 2	88	3.464 566 9
19	0.748 031 5	54	2.125 984 2	89	3.503 937 0
20	0.787 401 6	55	2.165 354 3	90	3.543 307 1
21	0.826 771 7	56	2.204 724 4	91	3.582 677 2
22	0.866 141 7	57	2.244 094 5	92	3.622 047 2
23	0.905 511 8	58	2.283 464 6	93	2.661 417 3
24	0.944 881 9	59	2.322 834 6	94	3.700 787 4
25	0.984 252 0	60	2.362 204 7	95	3.740 157 5
26	1.023 622 0	61	2.401 574 8	96	3.779 527 6
27	1.062 992 1	62	2.440 944 9	97	3.818 897 6
28	1.102 362 2	63	2.480 315 0	98	3.858 267 7
29	1.141 732 3	64	2.519 685 0	99	3.897 637 8
30	1.181 102 4	65	2.559 055 1	100	3.937 008
31	1.220 472 4	66	2.598 425 2		
32	1.259 842 5	67	2.637 795 3		
33	1.299 212 6	68	2.677 165 4		
34	1.338 582 7	69	2.716 535 4		
35	1.377 952 8	70	2.755 905 5		

NOTE: The inch values in this table are rounded off.

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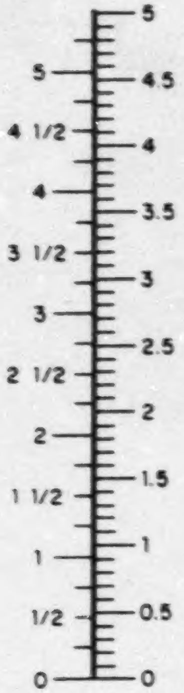
APPENDIX C

LENGTH CONVERSION CHARTS

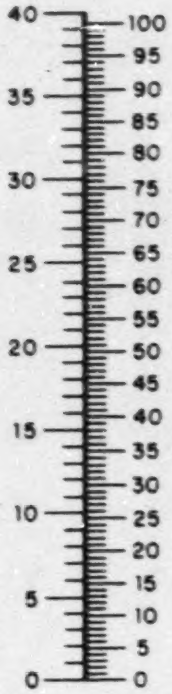
Yards – Meters



Each division on the left side of the above chart stands for ¼ yard, and each metric division (on the right) equals 0.1 m (or 10 cm).

(To convert *feet* to meters, first divide the number of feet by 3 to get yards.)

Inches – Centimeters

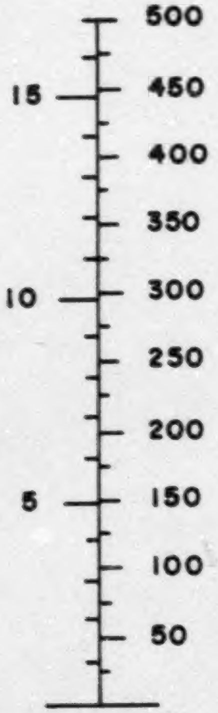


Each division on the left side of the above chart stands for one inch, and each metric division (on the right) stands for 1 cm.

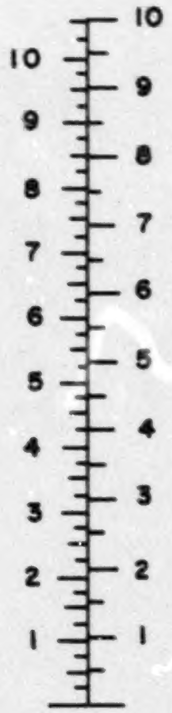
(To convert *feet* to centimeters, first multiply the number of feet by 12 to get inches.)

APPENDIX D

LIQUID CONVERSION CHARTS



Fluid Ounces – Milliliters



Quarts – Liters

Each division on the left side of the above chart stands for 1 fluid ounce, and each metric division (on the right) equals 25 milliliters.

(To convert *cups* to milliliters, first multiply the number of cups by 8 to get fluid ounces.)

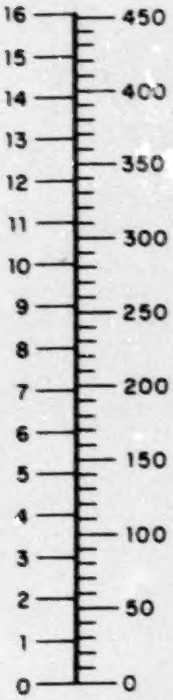
Each division on the left stands for one cup, and each metric division (on the right) equals 0.5 liter (or 500 milliliters).

(To convert *cups* to liters, first divide the number of cups by 4 to get quarts.)

APPENDIX E

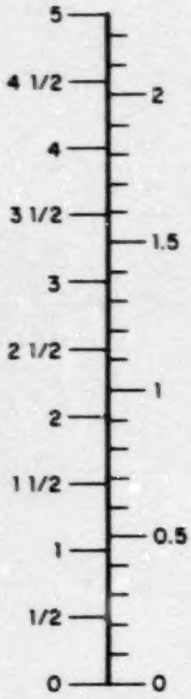
MASS (WEIGHT) CONVERSION CHARTS

Ounces – Grams



Each division on the left side of the above chart stands for 1 ounce, and each metric division (on the right) equals 10 grams.

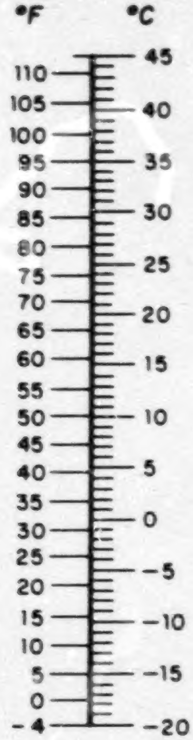
Pounds – Kilograms



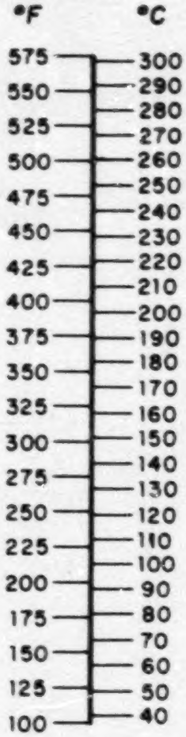
Each division on the left side of the above chart stands for ½ pound, and each metric division equals 0.1 kilogram (or 100 grams).

APPENDIX F

TEMPERATURE CONVERSION CHARTS


Fahrenheit – Celsius

Each division on the left side of the above chart stands for 5 degrees Fahrenheit, and each division on the right equals one degree Celsius.


Fahrenheit – Celsius

Each division on the left side equals 25 degrees Fahrenheit, and each division on the right equals 10 degrees Celsius.

APPENDIX G

CLOTHING METRIC MEASUREMENT CHARTS

Measurements for Ladies

Inches

Misses'

Size	6	8	10	12	14	16	18	20
Bust	30½	31½	32½	34	36	38	40	42 "
Waist	23	24	25	26½	28	30	32	34 "
Hip	32½	33½	34½	36	38	40	42	44 "
Back Waist Length	15½	15¾	16	16¼	16½	16¾	17	17¼ "

Miss Petite

Size	6mp	8mp	10mp	12mp	14mp	16mp
Bust	30½	31½	32½	34	36	38 "
Waist	23½	24½	25½	27	28½	30½ "
Hip	32½	33½	34½	36	38	40 "
Back Waist Length	14½	14¾	15	15¼	15½	15¾ "

Junior

Size	5	7	9	11	13	15
Bust	30	31	32	33½	35	37 "
Waist	22½	23½	24½	25½	27	29 "
Hip	32	33	34	35½	37	39 "
Back Waist Length	15	15¼	15½	15¾	16	16¼ "

Junior Petite

Size	3jp	5jp	7jp	9jp	11jp	13jp
Bust	30	31	32	33	34	35 "
Waist	22	23	24	25	26	27 "
Hip	31	32	33	34	35	36 "
Back Waist Length	14	14¼	14½	14¾	15	15¼ "

Young Junior/Teen

Size	5/6	7/8	9/10	11/12	13/14	15/16
Bust	28	29	30½	32	33½	35 "
Waist	22	23	24	25	26	27 "
Hip	31	32	33½	35	36½	38 "
Back Waist Length	13½	14	14½	15	15⅜	15¾ "

Women's

Size	38	40	42	44	46	48	50
Bust	42	44	46	48	50	52	54"
Waist	35	37	39	41½	44	46½	49"
Hip	44	46	48	50	52	54	56"
Back Waist Length	17¼	17⅜	17½	17⅝	17¾	17⅞	18"

Half-Size

Size	10½	12½	14½	16½	18½	20½	22½	24½
Bust	33	35	37	39	41	43	45	47 "
Waist	27	29	31	33	35	37½	40	42½ "
Hip	35	37	39	41	43	45½	48	50½ "
Back Waist Length	15	15¼	15½	15¾	15⅞	16	16⅛	16¼ "

Centimeters

Misses'

Size	6	8	10	12	14	16	18	20
Bust	78	80	83	87	92	97	102	107 cm
Waist	58	61	64	67	71	76	81	87 cm
Hip	83	85	88	92	97	102	107	112 cm
Back Waist Length	39.5	40	40.5	41.5	42	42.5	43	[illegible]

Miss Petite

Size	6mp	8mp	10mp	12mp	14mp	16mp
Bust	78	80	83	87	92	97 cm
Waist	60	62	65	69	73	78 cm
Hip	83	85	88	92	97	102 cm
Back Waist Length	37	37.5	38	39	39.5	40 cm

Junior

Size	5	7	9	11	13	15
Bust	76	79	81	85	89	94 cm
Waist	56	60	62	65	69	74 cm
Hip	81	84	87	90	94	99 cm
Back Waist Length	38	39	39.5	40	40.5	41.5 cm

Junior Petite

Size	3jp	5jp	7jp	9jp	11jp	13jp
Bust	76	79	81	84	87	89 cm
Waist	56	58	61	64	66	69 cm
Hip	79	81	84	87	89	92 cm
Back Waist Length	35.5	36	37	37.5	38	39 cm

Young Junior/Teen

Size	5/6	7/8	9/10	11/12	13/14	15/16
Bust	71	74	78	81	85	89 cm
Waist	56	58	61	64	66	69 cm
Hip	79	81	85	89	93	97 cm
Back Waist Length	34.5	35.5	37	38	39	40 cm

Women's

Size	38	40	42	44	46	48	50
Bust	107	112	117	122	127	132	137 cm
Waist	89	94	99	105	112	118	124 cm
Hip	112	117	122	127	132	137	142 cm
Back Waist Length	44	44	44.5	45	45	45.5	46 cm

Half-Size

Size	10½	12½	14½	16½	18½	20½	22½	24½
Bust	84	89	94	99	104	109	114	119 cm
Waist	69	74	79	84	89	96	102	108 cm
Hip	89	94	99	104	109	116	122	128 cm
Back Waist Length	38	39	39.5	40	40.5	40.5	41	41.5 cm

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Measurements for Children

Inches

Babies

Age	Newborn (1-3 months)	6 months
Weight	7-13 lbs.	13-18 lbs.
Height	17"-24"	24"-26½"

Toddlers'

Size	½	1	2	3	4
Breast	19	20	21	22	23"
Waist	19	19½	20	20½	21"
Approx. Height	28	31	34	37	40"

Children's

Size	2	3	4	5	6	6X
Breast	21	22	23	24	25	25½"
Waist	20	20½	21	21½	22	22½"
Hip	22	23	24	25	26	26½"
Back Waist Length	8½	9	9½	10	10½	10¾"
Approx. Height	35	38	41	44	47	48 "

Girls'

Size	7	8	10	12	14
Breast	26	27	28½	30	32 "
Waist	23	23½	24½	25½	26½"
Hip	27	28	30	32	34 "
Back Waist Length	11½	12	12¾	13½	14¼"
Approx. Height	50	52	56	58½	61 "

Chubbie

Size	8½c	10½c	12½c	14½c
Breast	30	31½	33	34½"
Waist	28	29	30	31 "
Hip	33	34½	36	37½"
Back Waist Length	12½	13¼	14	14¾"
Approx. Height	52	56	58½	61 "

Centimeters

Babies

Age	Newborn (1-3 months)	6 months
Weight	3-6 kg	6-8 kg
Height	43-61 cm	61-67 cm

Toddlers'

Size	½	1	2	3	4
Breast	48	51	53	56	58 cm
Waist	48	50	51	52	53 cm
Approx. Height	71	79	87	94	102 cm

Children's

Size	2	3	4	5	6	6X
Breast	53	56	58	61	64	65 cm
Waist	51	52	53	55	56	57 cm
Hip	56	58	61	64	66	67 cm
Back Waist Length	22	23	24	25.5	27	27.5 cm
Approx. Height	89	97	104	112	119	122 cm

Girls'

Size	7	8	10	12	14
Breast	66	69	73	76	81 cm
Waist	58	60	62	65	67 cm
Hip	69	71	76	81	87 cm
Back Waist Length	29.5	31	32.5	34.5	36 cm
Approx. Height	127	132	142	149	155 cm

Chubbie

Size	8½c	10½c	12½c	14½c
Breast	76	80	84	88 cm
Waist	71	74	76	79 cm
Hip	84	88	92	96 cm
Back Waist Length	32	34	35.5	37.5 cm
Approx. Height	132	142	149	155 cm

Measurements for Men and Boys

Inches

	Boys'				Teen-Boys'			
Size	**7**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
Chest	26	27	28	30	32	33½	35	36½"
Waist	23	24	25	26	27	28	29	30 "
Hip (Seat)	27	28	29½	31	32½	34	35½	37 "
Shirt Neck Size	11¾	12	12½	13	13½	14	14½	15 "
Height	48	50	54	58	61	64	66	68 "

Men's

Size	34	36	38	40	42	44	46	48
Chest	34	36	38	40	42	44	46	48 "
Waist	28	30	32	34	36	39	42	44 "
Hip (Seat)	35	37	39	41	43	45	47	49 "
Shirt Neck Size	14	14½	15	15½	16	16½	17	17½"
Shirt Sleeve	32	32	33	33	34	34	35	35 "

Centimeters

	Boys'				Teen-Boys'			
Size	**7**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
Chest	66	69	71	76	81	85	89	93 cm
Waist	58	61	64	66	69	71	74	76 cm
Hip (Seat)	69	71	75	79	83	87	90	94 cm
Shirt Neck Size	30	31	32	33	34.5	35.5	37	38 cm
Height	122	127	137	147	155	163	168	173 cm

Men's

Size	34	36	38	40	42	44	46	48
Chest	87	92	97	102	107	112	117	122 cm
Waist	71	76	81	87	92	99	107	112 cm
Hip (Seat)	89	94	99	104	109	114	119	124 cm
Shirt Neck Size	35.5	37	38	39.5	40.5	42	43	44.5 cm
Shirt Sleeve	81	81	84	84	87	87	89	89 cm

State of New Jersey
Department of Education
Division of Vocational Education

INTRODUCTION TO METRICS

Answer Book

Philip L. Edgecomb

Marion Shapiro

Vocational-Technical
Curriculum Laboratory
Rutgers – The State University
Building 4103 – Kilmer Campus
New Brunswick, New Jersey

MA–343 A

Page 5 (Unit II, Lesson 1)

1. a. .4
   b. .17
   c. .09
   d. .012
   e. .0072
   f. 7.03
   g. 53.0002
   h. 29.029

2. a. Two-tenths
   b. Eighty-four hundredths
   c. Six hundred twenty-one thousandths
   d. Three and seven-hundredths
   e. Seven hundred twenty-one thousandths
   f. Four and fifty-two hundredths
   g. Thirty-six and nine-thousandths
   h. Eight and three hundred seventy-two thousandths
   i. Six and six-hundredths
   j. Four and two hundred eight thousandths
   k. Sixteen and seventy-five thousandths
   l. Fifty-thousandths
   m. One and thirty-two ten-thousandths
   n. Ten and four thousand nine ten-thousandths
   o. Nine hundred ninety-eight thousandths
   p. One hundred forty-nine and seven-tenths
   q. Thirty-five and four hundred eighty-five thousandths
   r. Twenty-two dollars and ninety-eight cents

Page 8 (II – 2)

1. 100 dimes
2. 740 pennies
3. 540 dimes
4. 5400 pennies
5. 35 dimes
6. 3500 pennies
7. 4000 dimes
8. 1457 pennies
9. To the right. To multiply.
10. Multiply. To get more of the smaller units.

Page 9 (II – 3)

1. $47.82
2. $7.40
3. 80 dimes
4. 67 dimes
5. 26 dimes
6. $14
7. $14.50
8. $22.95
9. Left
10. Divide. To get fewer of the larger units.

Page 12 (II – 4)

1. a. meter
   b. centimeter
   c. kilometer
   d. kilometer
   e. meter

2. a. 10
   b. 10
   c. 10
   d. 10
   e. 10

3. a. .1
   b. .1
   c. .1
   d. .1
   e. .1

4. a. 1000 meters
   b. basic unit
   c. .01 meter
   d. .001 meter

5. 500 meters
6. a liter
7. Both the same
8. .01
9. Hectogram
10. by the thousand watt-hours

Page 16 (III – 1)

1. A. 3 cm 4 mm or 3.4 cm
   B. 4 cm 9 mm or 4.9 cm
   C. 6 cm 5 mm or 6.5 cm
   D. 8 cm 0 mm or 8.0 cm
   E. 9 cm 8 mm or 9.8 cm
   F. 10 cm 8 mm or 10.8 cm
   G. 12 cm 7 mm or 12.7 cm
   H. 14 cm 1 mm or 14.1 cm

2. A. 22.2 cm
   B. 23.8 cm
   C. 24.5 cm
   D. 25.4 cm
   E. 26.6 cm
   F. 28.0 cm
   G. 29.8 cm
   H. 31.9 cm

3. A. 21.6 cm
   B. 27.9 cm
   C. 4.2 cm
   D. 2.1 cm
   E.
   F.
   G.

4. A.
   B.
   C.

5. A. 8 mm
   B. 8mm 5mm 12mm 8mm 3mm 21mm
   C.
   D.
   E.

Page 19 (III – 2)

1. A. 10.2 m
   B. 3.9 m
   C. 12.5 m
   D. 142.8 m
   E. .6 m

2. A. 4.80 m
   B. 10.29 m
   C. 9.04 m
   D. 26.92 m
   E. .45 m

3. A.
   B.
   C.
   D.
   E.

Page 20 (III – 2)

Class Discussion *
1. millimeter
2. centimeters
3. meters
4. millimeters

5. a. centimeter
   b. centimeter
   c. centimeter
   d. kilometer
   e. meter
   f. millimeter
   g. millimeter
   h. meter
   i. centimeter
   j. centimeter
6. 5.5 cm – centimeters

* Note that the correct answer to these questions depends upon the wording of the question as well as the degree of accuracy desired. For example, "correct

to the nearest millimeter" can actually involve a *measurement* in *centimeters*. The first decimal place represents the millimeters, of course. This is a good opportunity for class discussion and further reinforcement of the concept of decimal parts of the different measures.

Page 22 (III – 3)

Class Discussion

1. More
2. About the same. Because .6 of 80 is 48, or about 50.
3. More
4. The track that covers a mile
5. Two more kilometers
6. 1000 m
7.

Page 23 (III – 3)

1. deka = 10 times
   hecto = 100 times
   kilo = 1000 times
2. A. meter Examples will vary.
   B. centimeter
   C. millimeter
   D. kilometer

Page 26 (III – 4)

1.
2. A. 21.6 cm → 216 mm E. (1) cm → m
   B. 27.9 cm → 279 mm E. (2) cm → m
   C. 4.2 cm → 42 mm F. cm → m
   D. 2.1 cm → 21 mm G. (1) cm → m
   G (2) cm → m
3. A. 8 mm → .8 cm
   B.(1) 8 mm → .8 cm
   C. mm → cm and mm → cm
   D. E. } Answers will vary.

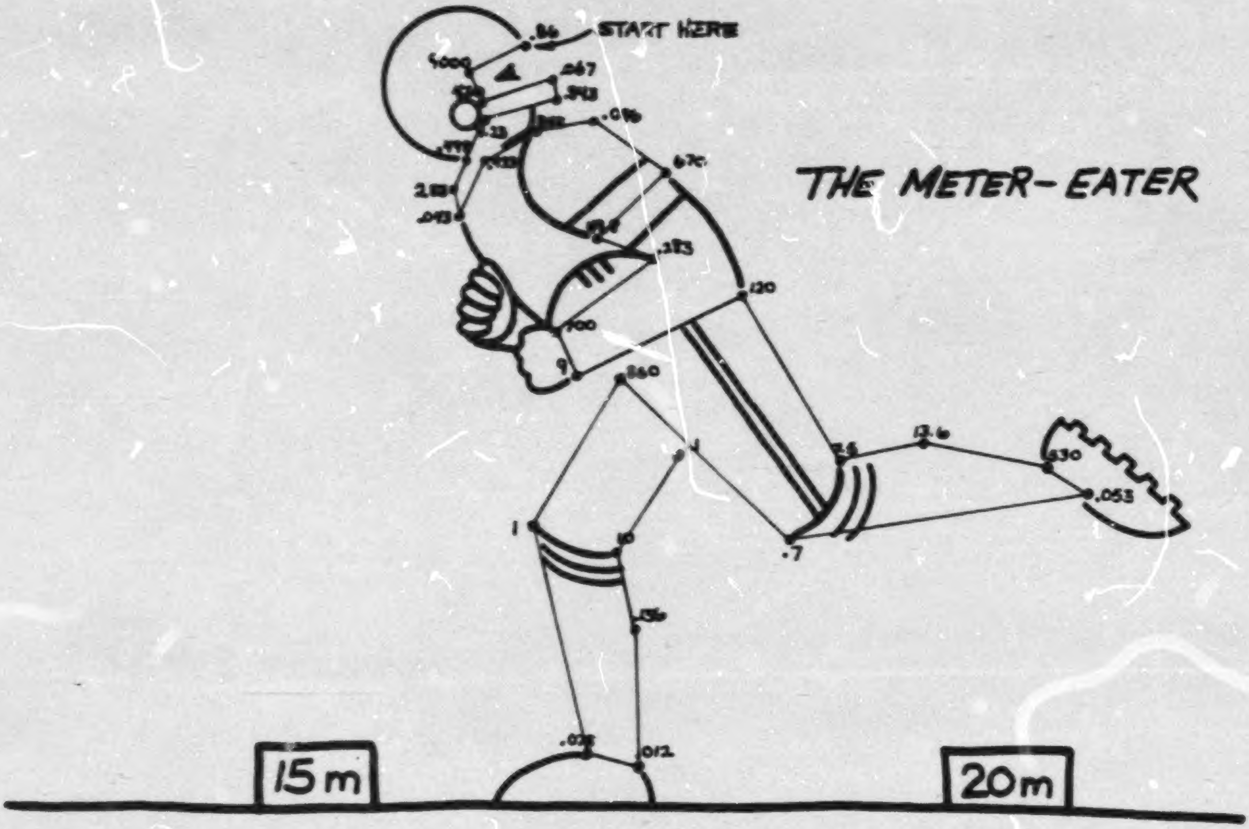
4. A. cm → m
   B. cm → m
   C. cm → m

5. A. m → cm
   B. m → cm
   C. m → cm
   D. m → cm
   E. m → cm

6. A. 316 cm
B. 15.72 m
C. 140 m
D. 21.425 km
E. 3.38 m
F. 4.936 m
G. 2,495 m
H. 16 cm
I. 72 mm
J. 14.3 m

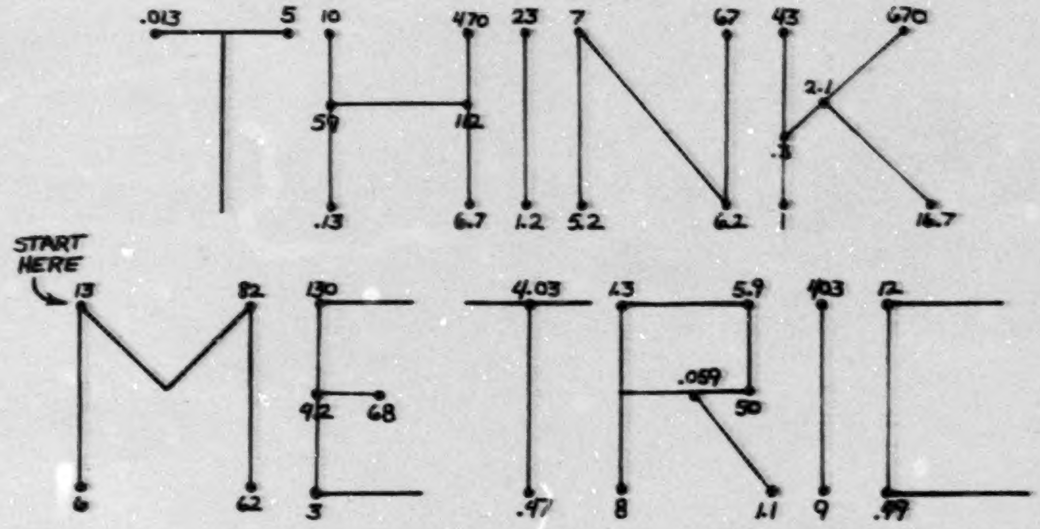
7. A. 220 cm
B. 14.9 cm
C. 720 mm
D. 40 mm
E. .042 km
F. .16 m
G. 350 dm
H. 1 km
I. .09 m
J. 2000 mm

Page 29 Problem 8


.86
START HERE
9000
.067
.843
.923
.086
670
2.83
.043
.283
120
700
9
860
.1
13.6
7.5
530
.053
.7
1
10
.136
.075
.012
THE METER-EATER
15m
20m

1.	8.6 mm =	.86 cm	16.	7 m =	700 cm
2.	9 m =	9000 mm	17.	.9 cm =	9 mm
3.	.43 km =	430 m	18.	.00012 km =	120 mm
4.	6.7 cm =	.067 m	19.	75 mm =	7.5 cm
5.	843 mm =	.843 m	20.	.0136 km =	13.6 m
6.	.923 cm =	9.23 mm	21.	5.3 m =	530 cm
7.	498 m =	.498 km	22.	53 mm =	.053 m
8.	28.3 mm =	2.83 cm	23.	.007 m =	.7 cm
9.	4300 cm =	.043 km	24.	.86 m =	860 mm
10.	923 m =	.923 km	25.	.1 cm =	1 mm
11	.843 m =	843 mm	26.	75 m =	.075 km
12.	86000 mm =	.086 km	27.	1200 cm =	.012 km
13.	.0067 km =	670 cm	28.	136000 mm =	.136 km
14.	4.98 cm =	49.8 mm	29.	.1 m =	10 cm
15.	28.3 cm =	.283 m	30.	1 mm =	.1 cm

9. BRAIN TEASER


.013
5
10
470
23
7
67
43
670
2.1
59
112
.3
.13
6.7
1.2
5.2
6.2
1
16.7
START HERE
13
82
130
4.03
1.3
5.9
403
12
.059
4.2
68
50
6
62
3
.47
8
1.1
9
.49

(a)

(b)

1. 8 m + 5 m = 13 m & 9 m - 3 m = 6 m
2. 8 m + 5 m = .013 km & 17 cm - 12 cm = 5 cm
3. 8 cm + 5 cm = .13 m & 43 km - 33 km = 10 km
4. 8 cm + 5 cm = 130 mm & 7 mm - 4 mm = 3 mm
5. 436 m + 764 m = 1.2 km & 32 cm - 9 cm = 23 cm
6. 8 cm + 2 mm = 82 mm & 9 cm - 28 mm = 62 mm
7. 6 cm + 7 mm = 67 mm & 9 cm - 28 mm = 6.2 cm
8. 6 cm + 7 mm = 6.7 cm & 1 km - 530 m = 470 m
9. 4 m + 3 cm = 4.03 m & 1 km - 530 m = .47 km
10. 4 m + 3 cm = 403 cm & 9.8 m - 0.8 m = 9 m
11. 5 cm + 20 mm = 7 cm & 9 m - 380 cm = 5.2 m
12. 4 cm + 3 mm = 43 mm & 0.7 m - 69 cm = 1 cm
13. 9 mm + 4 mm = 1.3 cm & 27 cm - 19 cm = 8 cm
14. 10 m + 200 cm = 12 m & 52 cm - 3 cm = .49 m
15. 365 cm + 225 cm = 5.9 m & 8 cm - 3 cm = 50 mm
16. 5 cm + 9 mm = 59 mm & 14 cm - 28 mm = 112 mm
17. 356 mm + 324 mm = 68 cm & 7 cm - 28 mm = 4.2 cm
18. 49 cm + 18 cm = 670 mm & 11 mm - 8 mm = .3 cm
19. 38 m + 21 m = .059 km & 3.9 mm - 2.8 mm = 1.1 mm
20. 8 mm + 13 mm = 2.1 cm & 18 m - 1.3 m = 16.7 m

10. MIX AND MATCH PUZZLE I

57 km .01 m 4 m .23 km	.023 hm 400cm .1 cm 5.7 mm	2.3 dm 1 mm 4 mm 57 m	.057 mm .4 cm .01 mm .023 km
230 m 400 km 4000 m 57 dm	.57 cm 4 km 10 m 2.3 cm	.057 km 1000 cm 40 mm 230 dm	23 m 4 cm 10 dm 57 cm
5.7 m .01 m .4 cm 57 mm	23 mm 4 mm 400 m 5.7 km	23 m .4 km 1 dm 2300 mm	570 mm 10 cm .4 mm 230 mm
5.7 cm .1 mm 40 mm 230 km	5700 m .04 m 10 dm 0.057 cm	230 cm 1 m 400 mm 23 cm	23 cm .4 m .04 mm 570 km

Page 34 (III – 5)

1. 25.2 meters
2. Perimeter is 92 cm.
   No. of holes varies acc. to layout – could be 92 or fewer.
3. 1170 m 1.17 km
4. 5.2 m
5. 16.2 m
6. 258 cm 2.58 m
7. 30.8 m 385 bricks
8. 113 holes
9. 59.6 m 271 bricks
10. 6.12 m 122.4 m

Page 37 (III – 6)

1. A. 75 mm or 7.5 cm
   B. 113 mm or 11.3 cm
   C. 12.9 cm
   D. 6.41 cm
   E. 518 cm or 5.18 m
2. A. 226 mm or 22.6 cm
   B. 239.3 mm or 23.93 cm
   C. 126 mm or 12.6 cm
   D. 77.2 cm
   E. 44.27 cm

3. 44 mm 276 mm
4. 5.2 cm 16.3 cm
5. 28.26 m 283 tiles
6. 314 cm or 3.14 m
7. 23.55 m 3.14
8. 112 bricks
9. 9.04 m
10. 79.17 cm 3.1416 13.19 cm
11. A. 45 mm
    B. 4 mm
    C. 35 mm
    D. 7 mm
12. 21.99 mm
13. 83 mm
    8.3 cm
14. 10 mm
    1 cm
15. 33 mm

Page 42 (IV – 1)

1. 35 cm^2
2.
3.

Page 45

1.
2.
3.
4.
5. 11.6 m^2
6. 21 m^2
7. 8.4 m^2
8. 18 m^2
9. 1.6 m^2
10 13.2 m^2

Page 48 (IV – 3)

1. 48 cm^2 96 cm^2
2. 15 m^2 75 m^2
3. (a) 400 cm^2
   (b) 405 cm^2
4. 315 m^2
5. 15.8 m^2

Page 50 (IV – 4)

1. 1500 m²
2. 15 m²
3. 32 m²
4. 111 m²
5. 44,000 m²
   4.4 hectares
6. triangle 15,400 m²
   rectangle 28,600 m²
   44,000 m²

Page 53 (IV – 5)

1. 7.1 m²
2. Inner area 78.5 m²
   Outer area 200.96 m²
   Area of walk 122 m²
3. 6359 cm² or .64 m²
   1741 cm² or .17 m²
4. 907 cm²
5. 5.3 m²
6. radius = 1.54 m
   A = 7.4 m²
7. 8 m²
   128 plants
8. 64.18 cm²
9. (a) 154 cm²
   (b) 314 cm²
10. 1.5 m²
    5078 cm²

Page 55 (IV – 6)

			Unit	Symbol Linear	Symbol Square
1.	a.	Textbook	centimeter	cm	cm²
	b.	Desk top	centimeter	cm	cm²
	c.	House ext.	meter	m	m²
	d.	Floor	meter	m	m²
	e.	House lot	meter	m	m²
	f.	Farm	meter	m	m² and hectare, ha
	g.	Township	meter	m	m², ha, or km²
	h.	Wire (cross sect.)	millimeter	mm	mm²

2. 4500 m²
3. .2194 ha
4. 20 m²
   2 l
   4 l
5. 154 cm²
6. 2112 cm²
7. 353 m²
8. .4606 ha

Page 57 (V – 1)

a. 24 m³
b. 192 m³
c. .14 m³
d. 30 m³
e. 23.9 m³
f. 52.5 m³

Page 58 (V – 1)

1. 17.3 m³
2. 232.6 m³
3. 1600 cm³
4. .154 m³ or 154000 cm³
5. 23.3 m³
6. 2.9 m³
7. 1.7 m³
8. 25344 cm³
   .025344 m³
9. 2.2 m
10. .6 m

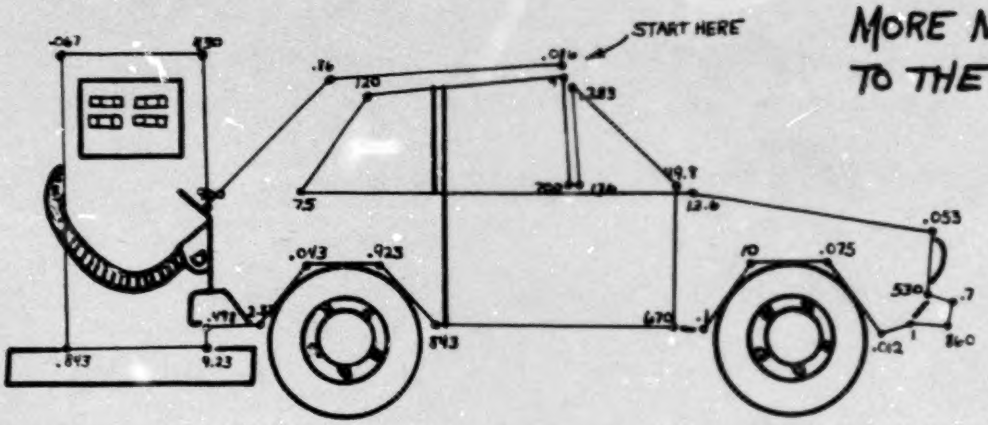
Page 62

1. A liter
2. 25¢ a liter
3. Larger
4. 4
5. 5 ml
6. 5 cm³
7. .005 l
8. 18 l

Page 63

9.

MORE METERS TO THE LITER


START HERE
.067
430
.86
120
.0136
.283
49.8
13.6
.053
.7
860
1
.012
530
10
.075
.1
670
843
.923
.043
2.83
.498
9.23
.843
900
7.5
700
136

1. 86 l = .086 kl
2. 860 ml = .86 l
3. .9 kl = 900 l
4. .43 kl = 430 l
5. 67 ml = .067 l
6. 843 ml = .843 l
7. 9.23 cm^3 = 9.23 ml
8. 498 l = .498 kl
9. 2.83 l = 2.83 dm^3
10. 43 l = .043 kl
11. 923 l = .923 kl
12. .843 l = 843 ml
13. 670 ml = 670 cm^3
14. 4.98 cl = 49.8 ml
15. 283 ml = .283 l
16. 136000 ml = .136 kl
17. 700 dm^3 = 700 l
18. .9 cl = 9 ml
19. 120 cm^3 = 120 ml
20. 7.5 l = 7.5 dm^3
21. .0136 kl = 13.6 l
22. 53 ml = .053 l
23. 5.3 l = 530 cl
24. .0007 l = .7 ml
25. .86 l = 860 ml
26. .1 cl = 1 ml
27. .012 m^3 = .012 kl
28. 75 l = .075 kl
29. 10 cm^3 = 10 ml
30. 100 ml = .1 l

Page 64

10. MIX AND MATCH PUZZLE II

(Volume Measure)

570 kl .04 ml 100 l 23 cm^3	23 cl .1 kl 40 kl 230 cl	.57 l 40 m^3 4 ml 57 l	23 kl 4 cm^3 .1 ml 5.7 cl
23 ml .4 ml 10 cl 570 ml	2300 ml 1 dl 400 dm^3 23 kl	.057 kl 400 l .4 l 23 ml	57 ml 400 ml .01 ml 5.7 l
57 cl 10 dl 40 cm^3 23 l	23 m^3 40 ml .01 kl 570 dl	2.3 cl 10 l 4 kl 570 l	57 dl 4000 l 400 kl 230 ml
.023 kl .01 ml 4 cm^3 .057 ml	57 l 4 ml 1 ml 2.3 dl	570 dm^3 .1 cl 4 dm^3 .023 ml	.23 l 4 l .01 l 57 kl

Page 67

1. 125.6 m^3
2. 418 m^3
3. 25.1 m^3
4. 4.6 m^3
5. 1648.5 cm^3
6. .22 m^3

7 (a) .350 m^3
(b) 350 l
8. 30,800 l
9. 5 ml
10. 180 m^3

Page 68

1. 1000
2. They are the same.
3. 1000
4. 3000 cm^3
3000 ml
5. 5 m^3

6. 452 m^3
452,000 l
7. 505 ml
8. 401.9 m^3
9. 9.5 kl
10. 9.5 l

Page 70 (VI – 1)

Class discussion

1. a. kilogram
b. kilogram
c. kilogram
d. gram
e. ton
f. kilogram
g. ton
h. ton
i. milligram
j. gram
2. Metric ton is 1.1 times an English (short) ton
3. 1 gram = .036 ounce
100 grams = 3.6 ounces

Problems

1. a. kilogram
b. fewer
c. divide by 2.2
d. multiply by 2.2
2. a. 3 kg
b. 3 g
c. 3 g

3. 1.2 kg
4. 60 kg
5. 36 t
6. 25 g
7. 1149 kg or 1.15 t
8. No. Total weight was 5.5 t.
9. Over by 105 mg or .1 g
10. 7.5 mg

Page 74 (VII – 1)

1. 32°F
2. 0°C
3. 100°C
4. 212°F
5. On the Celsius scale

6. 68°F
7. 20°C
8. 37°C
9. 98.6°F

Page 75 (VII – 2)

1. 39°C
2. −12°C
3. 36°C
4. 25°C
5. 76°C
6. −18°C

7. 160°C
8. 232°C
9. Water or brine 16°C
Oil 38°C to 60°C
10. Very slow 120° to 135° C
Slow 150° to 165° C
Moderate 175° to 190° C
Hot 205° to 245° C

Page 79 (VIII – 1)

Class discussion

1. Unified National Thread – UNC, UNF, UNEF
2. ISO metric threads
3. No.
4. It would be possible to replace damaged or missing screws and bolts anywhere in the world.
5. Standardization of screw threads – metric instead of inches and metric. Simplification – fewer sizes to manufacture, keep in stock, etc.
6. To make repairing and replacing of parts simpler.

Page 81 (VIII – 2)

1. 12 mm
2. a. 1.75 mm
   b. coarse-series
3. a. 16 mm
   b. 1.5 mm
   c. fine-series
4. a. 24 mm
   b. 2.0 mm
   c. fine–series
5. a. 24 mm
   b. 3.0 mm
   c. coarse-series
6. a. 16 mm
   b. 2.0 mm
   c. coarse-series